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Standardizing Army After Action Review Systems

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U.S. Army Research Institute

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The After Action Review (AAR) is the Army's approach for providing feedback to units after collective training exercises. AAR systems should support the goals of analyzing what happened during an exercise, deciding why it happened, and identifying potential corrective actions. In an effort to reduce duplication of efforts, the Army is developing a Standardized Army AAR System (STAARS) for application across the live, virtual, and constructive environments. This report presents lessons learned about the AAR process, operational AAR systems, and prototype AAR systems that provide input for specifying STAARS capabilities or identify technical or behavioral issues to be addressed by research and development.

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Training Systems and Education

FOREWORD

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has been actively involved in the development of After Action Review (AAR) methods and tools for the live, virtual, and constructive training environments beginning with the development of tactical engagement simulation in the mid-seventies. As part of the Army's Warfighter XXI program, the U.S. Army Training and Doctrine Command is attempting to develop a Standard Army After Action Review System (STAARS) for use across training environments that will help guarantee a certain level of AAR quality, reduce costly duplication in AAR system development, and provide exercise data to support advanced concepts requirements and research, development, and acquisition efforts. At the same time, the Simulation, Training, and Instrumentation Command has formed an AAR Integrated Product Team to leverage AAR system development efforts.

This report defines major variables to be considered in developing a STAARS, describes the state of the art and lessons learned in terms of AAR system capabilities, recommends specifications for a STAARS, and identifies behavioral and technological research and development efforts needed to support implementation of the STAARS concept. Most of the recommended specifications have been included in the STAARS Operational Requirements Document.

The work described in this report is a portion of research task 2114, SYNTRAIN: Distributed Interactive Simulation Systems. This task supports a Memorandum of Agreement entitled "Training Research Support of Combined Arms Tactical Trainer Development Efforts," signed 24 February 1993. Parties to this agreement are the U.S. Army Project Manager for Combined Arms Tactical Trainer and ARI.

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STANDARDIZING ARMY AFTER ACTION REVIEW SYSTEMS

EXECUTIVE SUMMARY

Research Requirement:

The U.S. Army is preparing to develop a Standardized Army After Action Review System (STAARS) that can be used within and across live, virtual, and constructive training environments. There is a need to define STAARS capabilities for a STAARS operational requirements document, and there is a need to define technical and behavioral research and development efforts necessary to make sure the technology base can support the STAARS concept.

ARI has had a long involvement in the development of AAR procedures and systems that includes two ongoing efforts to develop After Action Review (AAR) systems for the virtual environment and the organization of Army-wide AAR conferences. A review of published and unpublished findings of these efforts, combined with a review of literature relevant to other AAR systems, were examined to identify capabilities critical to a STAARS and to identify research and development issues that need to be addressed to support the STAARS concept. Topics addressed included adequacy of the variety of data displays available to support AARs, tools to help trainers conduct an AAR, tools to help trainers prepare Take Home Packages to supplement and reinforce teaching points from AARs, archiving of exercise data to support research applications, and human-computer interface issues.

Findings:

Substantial progress has been made designing AAR aids that can help trainers and analysts examine the performance of units more objectively, but there are still complex unit behaviors calling for innovative AAR aids. It is imperative that a STAARS provide users with the capability to implement new types of AAR aids integrating planning data, terrain data, communications data, behavioral observation data, and electronic data streams.

Standardizing AAR aids within echelons across training environments helps to ensure that the information contained in the aids will be readily interpretable to users, but there are also drawbacks to this approach. By limiting the exact design features of data displays for each echelon to those supported by data elements common to all three environments, the U.S. Army will throw out many of the benefits gained by moving toward electronic battlefields. STAARS should allow users to store and

analyze all electronic data produced within any of the three training environments.

Providing AARs at lower echelons shortly after the end of an exercise is a major challenge for an AAR system, and meeting this challenge requires automation of the AAR aids preparation process. Multiple AAR systems have been developed that analyze the network data stream to support the automatic generation of AAR aids, but there are many tactical events critical to the timing of AAR aid production that can only be recognized by a human being. At least one AAR system has demonstrated that automated AAR aid production can be accomplished using a mix of electronic data stream analysis and trainer responses to on-screen prompts. This latter system has also demonstrated the capability to move back in history and create AAR aids while it continues to collect exercise data. Automation must be applied carefully to the AAR aid preparation process because it can have the effect of distracting trainers from their exercise control functions.

Utilization of Findings:

Many of the findings from this research were used at the National Simulation Center as capability specifications and rationale for the STAARS Operational Requirements Document. These findings are also being used by the U.S. Army Simulation, Training, and Instrumentation Command's AAR Integrated Product Team to help integrate AAR system development efforts.

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STANDARDIZING ARMY AFTER ACTION REVIEW SYSTEMS

Introduction

The After Action Review (AAR) Process

The AAR is the Army's approach for providing feedback to units after collective training exercises. It is an interactive process in which exercise participants discuss mission planning and execution under the guidance of a trainer (Scott, 1983). The starting point for the AAR is normally a description of the unit's plans for the mission followed by a discussion of what happened during the mission (Department of the Army, 1993). The discussions might be guided in part, through the use of data displays illustrating what happened during an exercise. The goal of the AAR is to identify unit strengths and weaknesses in enough detail to point the way towards possible corrective actions (Downs, Johnson,& Fallesen, 1987).

An example of how interactive discussions might result in the identification of concrete corrective actions is as follows. A battalion task force sustained heavy losses and failed to hold its position in performing a defensive mission. The use of minefields and terrain features to force the enemy to move in an area covered by direct and supporting fires was a key part of the unit's plan for the mission, but no fires were used during a thirty minute period when the enemy's main body halted to breach a minefield. Discussions of what participants remembered about the exercise might reveal that the company team responsible for covering the minefield with direct fire was not in a position to observe it. Further discussions might reveal inadequate early coordination between the company teams and the engineers responsible for emplacing the minefield. The "corrective action" might involve the company team commander and the engineer platoon leader developing and applying a checklist of all the points on which they should coordinate.

The AAR process is intended to apply to live, virtual, constructive, and mixed environment exercises. A live exercise is one in which operational equipment and actual terrain is used, such as when a platoon maneuvers in its tanks. Virtual exercises involve the networking of simulators to make it possible for

crews to interact together on a common terrain database. Information produced by each simulator, such as its location on the terrain database, is transmitted over a network and picked up by other simulators. The graphics generator for each simulator employs network data and data from a common terrain database to provide a current "out the window" view of the world for crew members (Thorpe, 1987). Constructive simulations represent military units as an aggregate without simulating each entity within a unit (Stober, Kraus, Foss, Franceschini, and Petty, 1995), and this environment has been used largely to support command and staff training. A mixed or synthetic theater of war (STOW) environment contains a mix of live, virtual, or constructive environments (Sottilare, 1995).

Purpose of Report

This report describes the factors influencing the development of materiel and behavioral systems to support AARS in live, virtual, and constructive environments. This information is relevant to those responsible for defining the requirements for AAR systems, and it is relevant to research, development, and engineering (RD&E) organizations responsible for expanding the technology base to meet future training challenges.

Background

Figure 1 provides an overview of the process of developing AAR systems as it existed in the 1990 timeframe. This date is important because this was when AAR system users and the U.S. Army Simulation, Training and Instrumentation Command (STRICOM) were defining the requirements for the Close Combat Tactical Trainer (CCTT) AAR system. A description of user (e.g., the Armor school) requirements initiates the development process. To a large extent these requirements are based upon the users familiarity with the device being replaced. The next step in the process involves increased specification of requirements by looking at the technology base to examine current capabilities and technical issues relevant to the system under development (Meliza & Lampton, 1991). While examining the technology base, STRICOM engineers and other members of the government RD&E community provided feedback regarding the direction of future growth in the technology base. The specifications for most training devices automatically include those developed under the

ongoing series of workshops on the Standards for the Interoperability of Defense Simulations (Institute for Electrical and Electronics Engineers, 1993), frequently referred to as the Distributed Interactive Simulation (DIS) Standards.

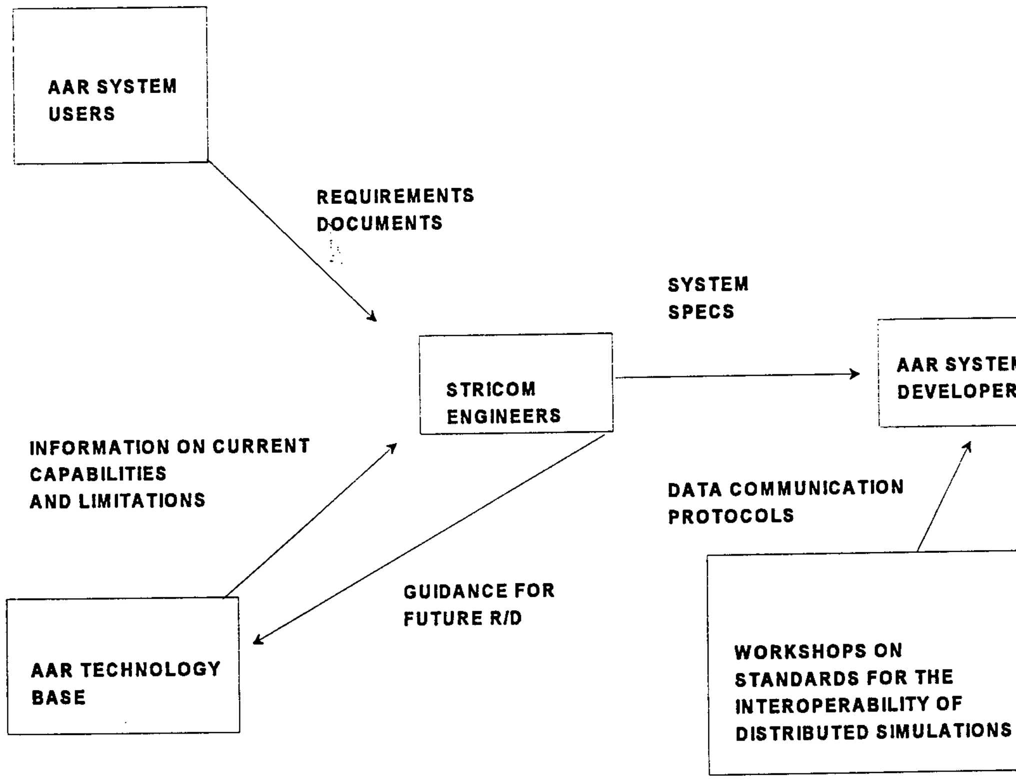

Figure 1. The AAR system development process Circa 1990

There were a number of problems with the process shown in Figure 1. First, users had very little experience with platoon and company level AAR systems to draw upon. Second, the technology base for AAR systems was in its early stages. Third, the DIS Standards did not reflect unit performance measurement and AAR system issues due to lack of experience. Fourth, the AAR system is only one component of the training system, and the requirements for an AAR system must be developed in coordination with other training components.

Simulation Networking (SIMNET), the networked simulation system to be replaced by CCTT was intentionally developed without

a performance measurement system (Alluisi, 1991). The first tools developed within the SIMNET program to support AARs were limited to animated replays from a plan view perspective or "out the window" perspective. The number of systems available to support AARs were often fewer than the number of exercises conducted concurrently at a training site, meaning that most AARs were conducted without the benefit of data displays (Goldberg and Meliza, 1993).

Attempts to implement systems with added measurement capabilities were frustrated by periodic changes in the SIMNET data stream, requiring software changes in the measurement system. For example, the Unit Performance Assessment System (UPAS) was developed to support measurement with SIMNET Version 5.0 just as this version was replaced by 6.0 (Meliza, Bessemer, & Tan, 1994). A version of the UPAS capable of using SIMNET 6.0 data was ready for testing just as SIMNET Version 6.6.1 replaced 6.0. Fortunately, 6.6.1 was the last version of SIMNET. The upgrade of the UPAS to SIMNET 6.6.1 allowed testing of the software in its application to AARs.

By 1993, we were collecting lessons learned from various SIMNET AAR systems and performance measurement systems that could provide input for refining the requirements for CCTT AAR systems as well as requirements for AAR systems for other training devices. A new problem emerging was the duplication of efforts to develop AAR systems. The Project Manager for Combined Arms Tactical Trainer (PM-CATT) asked ARI to organize an Army AAR Conference for early 1994 in an effort to reduce redundancy in efforts to develop AAR systems and to help formalize and standardize Army requirements for AAR systems. An important part of this conference was the demonstration of new and developing AAR capabilities and lessons learned. This conference included the live, virtual and constructive training environments under the assumption that they have common AAR requirements. The presentations, discussions, and conclusions from this conference were documented and distributed by ARI (1994).

One important finding from this conference was that AAR system requirements cannot be defined in isolation from other components of training, such as the exercise management system. Sponsorship for the second AAR Conference, held in April of 1995 and again organized by ARI, increased to include the U.S. Army

Training and Doctrine Command (TRADOC) Assistant Deputy Chief of Staff for Training and the Commanding General of STRICOM. A major benefit of this new alliance is that it brought the AAR Conference into the Warfighter XXI program under which the AAR system is one of five integrated training components (Marlin, 1995). The first is the Standard Army Training System (SATS) component with the mission of automating training management to make more effective use of training resources. The second component is Training Support Packages (TSPs) with the mission of providing an automated, structured situational training template resourced to generate training events. This component will provide scenarios for use with specific training aids, devices, simulations, and simulators (TADDS). The third component is the TADDS with the mission of providing integrated and effective training tools to efficiently train a unit. The fourth component is the Standard Army AAR System (STAARS) with the mission of providing a standardized, automated storage and distribution system to support training evaluation, resource utilization and data analysis for lessons learned efforts. The fifth component is the Army Training Digital Library (ATDL) with the broad mission of providing access to information to assist Army trainers.

The Warfighter XXI strategy is intended to address the total Army, employ institutional and self-development strategies tailored to support collective training, be supportable with limited resources, and make use of future technologies and capabilities. The last two requirements impose two critical certain restrictions on how the Army must develop future training systems; the Army must avoid redundant development and experimentation, and the Army must not adopt technological solutions to problems too soon.

The presentations and findings of the Second AAR Conference were summarized by the ARI Simulator Systems Research Unit (1995). The addition of Warfighter XXI, STAARS, and AAR Conferences has many effects upon the AAR system development process as illustrated in Figure 2. The development and application of AAR systems has expanded the technology base, provided users with examples of current capabilities, identified problems to be addressed by the technology base, and provided

input to the DIS standards. In addition, these research and development efforts have provided input to Warfighter XXI and the development of STAARS.

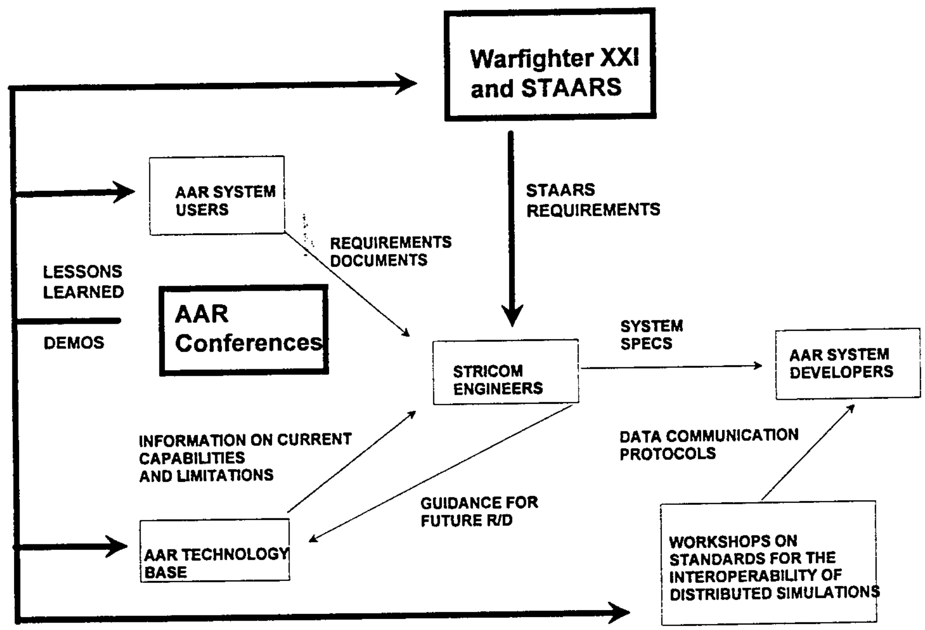

Figure 2. Effects of Warfighter XXI, the STAARS, and AAR conferences on the AAR system development process

The core capabilities of a STAARS were briefly described in an iterative fashion culminating in a Nov 95 STAARS Mission Needs Statement (MNS). According to the MNS document, STAARS must:

o be compatible and interoperable in the constructive, virtual, and live environments to include joint and combined systems;

o compare unit performance to doctrinal standards and lessons learned from other training events;

o provide high quality standardized AAR products appropriate to the echelon(s) being trained or analyzed;

- o retrieve, display, and distribute feedback without disrupting the TADSS, test, experiment, or training exercise;

- o standardize the automated storage, distribution, and retrieval of AAR data within the ATDL architecture;

- o provide for identification of specific events by using tailored parameters to alert the user; and

- o provide standardized user definable products incorporating playback capability, C4I (command, control, communication, computers, and intelligence)/video products, access to doctrinal sources, statistical products, terrain analysis, and trainer observations.

An initial STAARS action plan has been developed to provide milestones and responsibilities for the iterative development of STAARS. This plan assumes iterative development of the STAARS over the next ten years. A key milestone is the development of a STAARS Operational Requirements Document (ORD) in FY96 with the National Simulation Center (NSC) serving as the lead agency.

The goal of the third AAR Conference, held in Jan 96, was to revise a draft ORD and expand upon the STAARS Action Plan. The remainder of this report provides input to the ORD and Action Plan.

The series of DIS Standards Conferences that began in Aug 89 are concerned with describing what a simulation system must do to interoperate with other systems (Institute for Simulation and Training, 1992). The initial output from the DIS Standards Conferences relevant to the development of AAR systems was limited to a standard (Institute of Electrical and Electronic Engineers, [IEEE] 1993) providing descriptions of the network data stream or protocol data units (PDUs) used to support the communication of information among entities. The input from the Conference has expanded to include a draft document describing recommended practices for exercise management and feedback in the DIS environment (Institute for Simulation and Training, 1995) and a document presenting the rationale behind the recommended

practices (Institute for Simulation and Training, 1994). The present report describes relationships between DIS standards and the STAARS concept.

Designing AAR Aids to Help Document What Happened, Explain What Happened and Identify Potential Corrective Actions

Background

AAR "systems" should support the goals of analyzing what happened during an exercise, deciding why it happened, and identifying potential corrective actions. Analysis of outcome data must go beyond battle damage assessment (e.g., counting the number of weapon systems on each side that are damaged or destroyed) to include examination of key mission subtasks by answering such questions as: was the unit slow to respond to enemy contact? Did the unit apply an adequate volume and mix of fires against the enemy? Were fires distributed appropriately among specific targets or areas?

At many points during the AAR the "data" used to examine the exercise shifts from external representations of ground truth to the knowledge and memories of exercise participants. This shift is often essential to the goal of diagnosing performance problems to a point that supports the identification of specific corrective actions. In looking through the list of performance problems in Table 1, note that none could be identified without information from participants about their perceptions of events and knowledge of tactics, techniques, and procedures (TTPs).

Table 1.

List of Representative Performance Problems that might be Identified during an AAR

o Unit members have not learned existing standard operating procedures (SOPs) or are confused about SOP interpretation
o Important information in general (or of a specific type) is not being disseminated up or down the chain-of-command
o The SOP of one unit is not compatible with that of another
o There is confusion about the purpose and scope of a unit task or about how to apply a particular tactical principle
o Subordinate leaders have a difficult time analyzing the tactical situation or applying the results of their analyses.

STAARS and DIS Standards Guidance

The MNS for the STAARS contains three capabilities statements that relate to the design and content of AAR aids. First, the system must provide the capability to compare unit performance to doctrinal standards and lessons learned from other training events. Second, the system should be compatible and interoperable in the constructive, live and virtual environments, and it should provide high quality standardized AAR products appropriate to the echelons being trained or analyzed. Third, STAARS will provide standardized user definable products incorporating playback capability, C4I/video products, access to doctrinal resources, statistical products, terrain analysis, and observer/controller (O/C) observations.

The recommended practices for exercise management and feedback in the DIS environment address data collection, presentation, and analytic functions (Institute for Simulation and Training, 1995). Many of these recommended practices concern the PDU data stream used to communicate information among

entities in a networked exercise, such as the Entity Appearance PDU stream generated by each entity to convey information about its status to other entities. According to the recommended practices document, a DIS feedback system should:

- o reproduce the PDU stream exactly as received;
- o archive non-PDU data important in examining unit performance and index to the PDU data;
- o archive the PDU and non-PDU data in a manner that supports analysis within and across exercises;
- o allow user to select PDUs to be collected from the network;
- o support selectable checks to validate events determined by two or more PDUs (e.g., a detonation PDU should be associated with each fire PDU);
- o provide an out-the-window view of the exercise with a viewpoint selectable by the user;
- o provide a plan view of the exercise that depicts entities, topographic features, cultural features, and user-defined annotations (e.g., control measures) and allow user to select what is to be depicted;
- o pan, zoom, and adjust map display scale;
- o control playback with fast forward/reverse, jump forward/reverse (move forward or back to specific points in time without replaying all of the interpolated data), selection of play speeds, single frame movement, and pause/freeze capability;
- o support playback audio;
- o provide hardcopy outputs of displays;
- o allow the user to select specific entities or classes of entities for replay;
- o show environmental effects;

o show movement of articulated parts;

o support overlay of non-PDU data (e.g., control measures);

o replay exercises at a level appropriate to the exercise participants being debriefed against appropriate environmental models using changes in entity icons and other graphical aids to indicate all relevant variables and status changes;

o display data on line-of-sight among entities on command;

o support user editing of displays; and

o support user customization of tabular displays and figures including graphs, tables, summaries and time lines showing critical exercise events as defined by the user.

History and Status of Research

Historical Perspective. The development of data displays to support AARs is a young endeavor. The move towards tactical engagement simulation (TES) with Squad Combat Operations Engagement Simulation (SCOPES) and realistic training (REALTRAIN) in the seventies might be considered a start point for the development of AAR aids by providing engagement outcomes that were more objective than the opinions of field umpires (Anderson & Sherwood, 1975). The subsequent adoption of the Multiple Integrated Laser Engagement System (MILES) in live exercises as the approach for simulating weapons effects further enhanced the objectivity of mission outcomes (Loftis, 1980; Sulzen, 1986). The data displays used for AARs were generally limited to those reflecting casualty exchange ratios.

The subsequent move towards instrumented ranges at the National Training Center (NTC) in the early eighties further increased the data available to describe what happened during exercises. These data included TES combined with position location data that could be displayed over plan view maps, and it included videotapes of the battlefield and recordings of tactical communications. With few expectations, the data displays at the NTC focused on battalion task level performance rather than company or platoon-level. Further, there were problems with the

quality of the TES data resulting in a situation where only a small percentage of casualties could be linked to specific firing events (Walsh & Keesling, 1993).

The addition of networked simulators to create an electronic battlefield in the mid to late eighties greatly increased the data that might be used for preparing AAR aids. For example, we went from a situation where vehicle status data were limited to periodic updates regarding the location and damage status of vehicles to the point of having near continuous updates on the locations of vehicles, the speed at which vehicles were moving, the orientation of vehicles, engine speeds, the orientation of gun tubes, the elevation of gun tubes, fuel levels, and ammunition levels (Meliza, Bessemer, and Tan, 1994). However, as mentioned on page four of this report, efforts to develop data displays using these new sources of data for training feedback displays did not meet with much success until the early nineties.

The initial SIMNET did not have the capability to provide data displays that could be used to assess performance (Alluisi, 1991). In the past five years we have learned important lessons about the design of data displays and about the capability of networks to provide the data we need to create effective displays.

Using AAR Aids to Show Ground Truth. AAR aids can play the important role of documenting what happened during an exercise. One of the major benefits of moving towards an electronic battlefield is that it makes it easier to document what happened during an exercise. Instead of a trainer telling a unit that it failed to provide adequate returning fire when engaged by the enemy, the trainer can replay a portion of the exercise showing slow and meager unit fires against a heavy volume of enemy fires or provide a graph summarizing the same information. Exercise participants can then see for themselves what happened and reach their own conclusions about how well they employed direct fire against the enemy.

Comparing Behavior with Doctrinal Standards and Lessons Learned. The purpose of collective performance measurement is to find out how well individuals work together in performing group tasks. For Army organizations, these tasks are defined in Mission Training Plan (MTP) documents (U.S. Army Training and

Doctrine Command, 1984), such as the MTP for the Tank Platoon (Department of the Army, 1988). MTP documents include standards for evaluating how well a unit performs each task and subordinate subtasks. For example, the overall standard for the task of "execute a wedge formation" is "the platoon executes the wedge formation without delay and without stopping movement". There are also subtask standards that might be viewed as descriptions of task steps. One standard for the subtask "the platoon executes the wedge formation without delay" is "Plt ldr positions himself at either the 1 o'clock or 11 o'clock position where he can best control his platoon and according to his SOP."

In addition to comparing unit performance with performances described in doctrinal standards, an AAR system should also help a trainer compare the behavior of a unit with descriptions of the behavior of successful and unsuccessful units. For example, the Center for Army Lessons Learned (CALL) has examined performances of units at the NTC and described actions typical of well trained or inadequately prepared units. As part of this larger effort, Goldsmith and Hodges (1987) prepared a report containing recommendations for improving tactical reconnaissance at the battalion level, based upon lessons learned at the NTC. Of course the Army wants to provide units with displays that can be used to quickly see what other successful units do in a specific situation, rather than providing the unit with a report to read and analyze. This approach fits the "A way" concept recommended by LTG (Ret) Brown whereby units are shown a display that shows one way of doing something that led to success, without implying that it is the only way to be successful.

The displays that might be used to compare the performance of a unit with standards or lessons learned are not limited to those that illustrate the outcomes of mission and task performance. They might include, for example, a list of innovative command and control procedures used by units at the NTC to make more efficient use of dozers when preparing for defensive operations. The items on this list might be compared with what unit members remember doing to support efficient dozer use during a CCTT exercise to see if there are new ideas on the list from the NTC. That is, it may not be necessary to have a display based on the activities of the unit in CCTT.

Importance of Being Able to Rapidly Interpret the Information Contained in AAR Aids. An important component of the STAARS concept is the standardization of AAR aids for each echelon across training environments. If a tank platoon is using SIMNET to conduct training in preparation for training at the NTC, then the aids used for SIMNET exercises should be the same as those used for tank platoons at the NTC. A major benefit of standardizing displays across environments is that it links exercises with capstone training environments, such as rotations to a combat training center (CTC). For example, if a CTC employed a particular data table to show how well a unit kept its vehicles ready for combat, units would want to see the same table after participating in virtual exercises.

It is important that the displays used be immediately interpretable to exercise participants. If many minutes are required to explain what a display means then it will be of little or no value in the training environment. Standardizing of displays within echelons and across training environments helps to make sure that exercise participants will be familiar with the displays presented in AAR sessions.

Using AAR Aids to Support the Trainer's Analysis of Unit Performance. Data displays play at least three different roles in the AAR process (Meliza, Bessemer, Burnside, & Shlechter, 1992). First, the trainer may use aids to illustrate the strengths and weaknesses to a unit. Second, they can be used to suggest alternative courses of action to a unit. Third, a trainer may use displays to diagnose the strengths and weaknesses of a unit in preparation for conducting the AAR. It is crucial that aids used for the first two purposes be immediately interpretable to all exercise participants, but aids used for the third purpose do not need to meet this requirement. However, we do want to make sure that very little time is required to prepare users to employ AAR aids in diagnosing unit training needs.

Measures of the degree of dispersion of vehicles within a battalion task force have been shown to be correlated with mission outcomes at the Army's NTC (Goehring & Sulzen, 1994). Too much time might be required to explain these data displays and statistics for them to be employed during an AAR, but the analyses can be used to assess command and control strenghths and weaknesses on which a trainer might want to focus during the AAR.

To use such displays for diagnostic purposes, the program of instruction (POI) for the system user must incorporate training on how to use these displays or the system should apply these displays in a manner that is transparent to the user (e.g., provide the user with the interpretation of the display rather than showing the display to the user).

Substantial research and development activities are required to develop data displays that can be used to measure unit performance and/or diagnose unit strengths and weaknesses. Once such diagnostic tools have been developed there may often be a need to design new displays that help to illustrate strengths and weaknesses during the AAR. For example, in the case of the measures of dispersion related to mission outcomes, we need ways to let a leader see that his forces are too spread out to support effective execution of mission tasks.

The Need for New AAR Aids. Conduct of training in an electronic battlespace supports preparation of AAR aids by providing data in an electronic format, but network data alone are not sufficient to measure unit performance. Consider the standard "platoon occupies position designated in operations order and moves to turret-down positions" from the task "perform consolidation and reorganization activities" from the MTP for the Tank Platoon (Department of the Army, 1988). To apply this standard one must know the locations of vehicles (from network data), the position designated in the operations order (from planning data), and the terrain situation (from the terrain database). Deciding how well a unit performed with respect to MTP standards often requires a mix of network data, data on radio communications, planning data, terrain data, and direct observations of human behavior (Meliza, 1993b). Further, complicating the process of applying these diverse data sources is the fact that these data must also be considered as a function of time.

Innovative design work is needed to create displays that bring together data from mixed sources over time. One example of such an aid is the UPAS Firefight Display, designed by a trainer who saw the need for a display to help decide where and when a unit concentrates direct and supporting fires (Meliza, Tan, & Bessemer, 1994). A Firefight Display (Figure 3) shows direct and indirect firing events over a terrain map, covering a user

selectable period. Direct firing events are displayed with shot lines connecting the location of the firing vehicle with that of the vehicle or ground impact, and a vehicle icon is used to show the location of the firing vehicle using the same color coding system as the UPAS Plan View. A miss is indicated by a white line, and a green line indicates a hit or a catastrophic kill. If the firing event results in a kill, there will also be a dead vehicle icon at the target location (cyan for a destroyed BLUFOR vehicle and white for a destroyed REDFOR vehicle). Artillery impacts are shown using white rectangles.

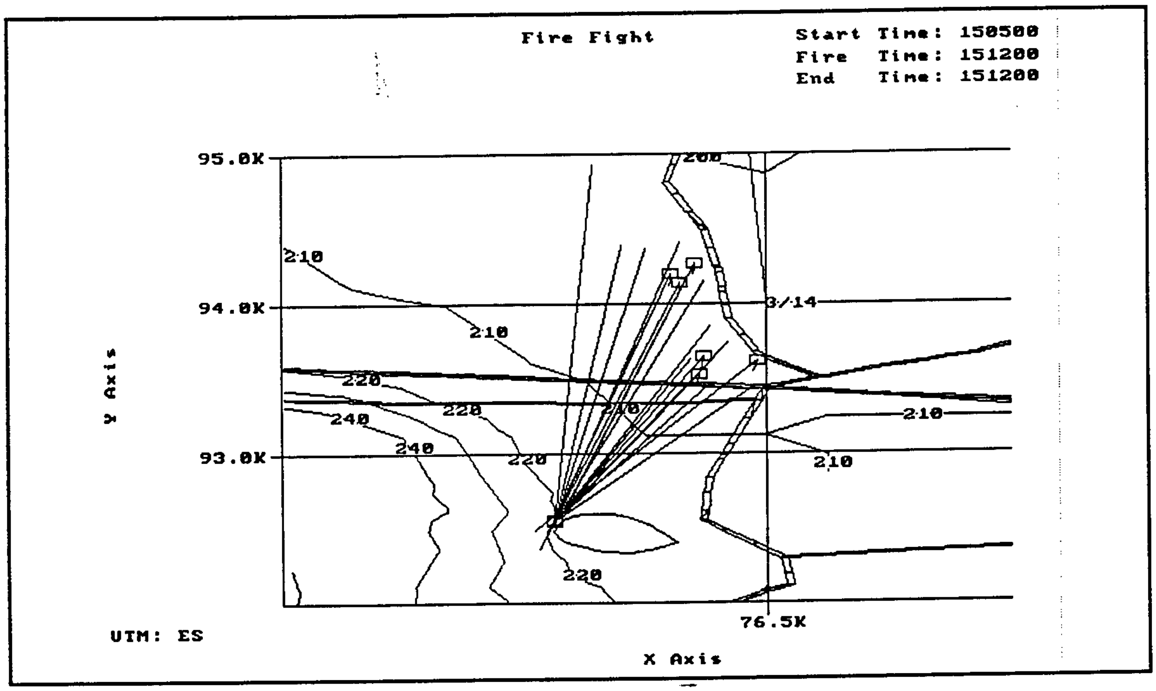

Figure 3. Example of a fire fight display

The UPAS Exercise Timeline is another example of an AAR aid that integrates a mix of data over time. The Exercise Timeline describes firing, movement, and communication events as a function of time and control measures to help make it more obvious how different kinds of events are related in time. The Exercise Timeline can be used to identify points in time that warrant examination using other data displays, and it can be used by itself to assess unit performance. For example, one might use the Exercise Timeline to find out if a platoon in the offense halted soon after being engaged by (or engaging) the enemy and promptly reported contact.

Figure 4 provides an example of an Exercise Timeline. The top line covers the time between the start and end of the exercise, but the user can change the display to focus on a smaller span of time. The second line describes platoon movement as a function of time and unit control measures. The bars at the bottom of this line indicate when the first and last vehicle of a unit crossed a control measure. In the example, LD Tin and Assembly Area Gold were right next to each other, so the times for vehicle crossing are identical. The unit crossed Phase Line Silver quickly but crossed Phase Line Bronze as sections with the rear element overwatching fire and maneuver of the lead element.

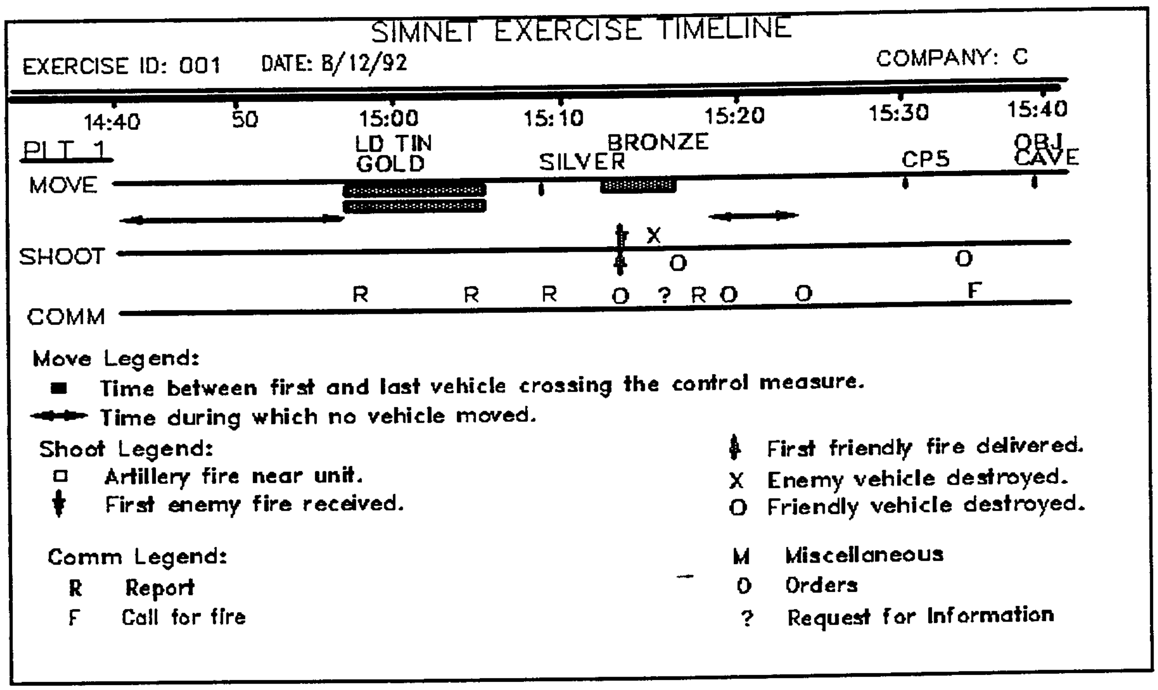

Figure 4. Example of an exercise timeline

Disabled or destroyed vehicles are not counted in computing when control measures are crossed. The Exercise Timeline also indicates the beginning and ending of periods when the entire platoon was halted.

The third line provides information about the time of direct and indirect fires. A small square is used to indicate the platoon received artillery fire, an arrow pointed down indicates

the first enemy direct fire was received by the platoon, an arrow pointed up indicates the first platoon fires on the enemy, a small "x" indicates when an enemy vehicle is destroyed, and a small circle indicates when a friendly vehicle is destroyed.

The fourth line provides information about the timing and type of communications over the tactical radio network. The communication line of the Exercise Timeline for each platoon and the company commander indicates when each of five types of tactical communications are transmitted by the platoon or company commander over the company net. An order is indicated by an "O", a report is indicated by an "R", a call for fire is indicated by an "F", and a request for information is indicated by a question mark. Tactical communications that do not fall into one of these four types are classified as miscellaneous and indicated with an "M" on the Exercise Timeline.

An example of new type of display developed for use in the constructive environment is a version of an overhead snapshot of the battlefield showing the density of coverage of various areas of the battlefield by friendly weapons (Fernan & Dryer, 1994). This figure is created by assessing the line-of-sight fans from each friendly system and considering the number of systems having line-of-sight with each point. An example of an innovative live display is that used by Goehring and Sulzen (1994) to assess dispersion of forces at the NTC.

There is still a need for new types of innovative displays, because unit performance measurement is a complex challenge. In many cases, a half dozen or so data displays might be required to thoroughly examine an aspect of unit performance, due to the fact that unit actions should reflect the overall mission, enemy, terrain (and weather), troops, and time available (METT-T) situation. For example, a unit might fail to return fire at a particular point, because:

o the enemy is out of range;

o fires are masked by another friendly element;

o the unit is not aware it is being fired upon;

o line-of-sight is blocked by terrain features;

- o the unit believes it has not actually been sighted by the enemy and will give away its position if it fires;

- o unit SOP specifies that fires are to be withheld until the leader gives a fire command but the leader is dead or has communication problems; and

- o the unit is out of ammunition, has suffered catastrophic kills and firepower kills from previous engagements.

New types of data displays might integrate information across existing data displays or otherwise reduce the number of potential displays a trainer might need to employ. Unfortunately there is no source one can use to identify all of the standards for which we need improved data displays. However, there is an online database that identifies the data sources (network, terrain data, planning data, communications data, and direct observation of the behavior of humans) needed to apply each of approximately 5000 MTP standards at the armor platoon, company team, and battalion task force levels (Meliza, 1993b).

Hixson (1996), in a description of AAR requirements for exercises at brigade level and higher supported by the Corps Battle Simulation (CBS) AAR system, brought up the important point that more of the critical feedback for these exercises is based upon direct observation of humans and less is based upon electronic data. To obtain these data requires the development of a detailed data collection and analysis plan that integrates data collected across observers. Integration is required to, for example, provide information that can be used to assess how well the maneuver planning and monitoring process is synchronized with the logistical planning and monitoring process.

Measuring Generic Team Skills. Another approach to assessing unit performance and identifying potential corrective actions might focus on team behaviors that are not task specific, such as examining patterns of communication (Blickensderfer, Cannon-Bowers, & Salas, 1994; Urban, Bowers, Monday, & Morgan, 1993). Urban et al., for example, showed that poor performing teams used a question and answer sequence to communicate information, while higher performing teams were less likely to use questions to prompt the dissemination of information. That is, members of high performing teams appear to anticipate the information needs

of other team members and provide this information without being asked.

The Teamwork Observation Measure (TOM) is an example of a tool that can be used in assessing team skills across collective tasks. This instrument was recently applied in measuring team performance during the planning, contact point, and attack phases of close air support (CAS) missions (Bell, Dwyer, Love, Meliza, Mirabella, & Moses, in preparation). The same instrument was used across each phase of CAS for multiple CAS missions, providing an opportunity to assess whether there are trends in teamwork skills and deficiencies. Teamwork was assessed in terms of the general areas of communication, coordination, situational awareness, and adaptability using the prompts and rating scales.

Evaluating User Acceptance of Displays. Shlechter, Bessemer, Rowatt, and Nesselroade (1994) collected comments from trainers regarding their opinions of various UPAS data displays. These researchers found that ratings of displays are influenced by such factors as the combat mission being trained/evaluated, the time and effort required to use the display, specific design features of the display (background contrast), display control features (e.g. fast forward capability), rank of the trainer, echelon to be trained, and experience using the display.

Additional research is needed to gain information about the utility of specific types of displays as a function of key variables. However, the work by Shlechter et al., (1994) identified certain capabilities that need to be called out in requirements documents. First, the system must have a "fast forward" capability to support use of replays during AARs. Second, the system must allow the user to match vehicle bumper numbers with specific icons. Third, users want access to line-of-sight data.

The capability to fast forward through replays does not necessarily meet the need of the trainer to quickly identify key tactical events and replay these for exercise participants. For example, unless the system can move backwards in exercise history it will be difficult for the user to focus in on critical actions and replay these actions at normal speed. Other capabilities that might combine with fast forwarding to meet the needs of trainers are the capability to move directly from one point in

time to another and the capability to step forward or backward from a point in one second increments.

"Out-the-window Views". Many leaders emphasize the utility of out-the-window views during AARs. "Out-the-window" views allow a unit to see a replay of an exercise from the same perspective it had during an exercise or from the enemy's perspective. As in the case of other types of AAR displays, we still know very little about which aspects of performance can be examined most effectively using this view.

A weakness in the control of some versions of this display is that it allows the observer to get lost when moving around the battlefield. The Simulation Training Integrated Performance Evaluation System (STRIPES) provides the capability to observe a plan view and "out-the-window" view concurrently on the same screen. A plan view icon shows where the "out-the-window" view is located and oriented.

Strategies for Helping Aids Make Teaching/Training Points. Another area of display enhancement concerns focusing the attention of units on specfic training points. In the case of the UPAS, this was accomplished by giving the user the capability to save a screen and add up to two lines of comments for display with the screen. For example, a UPAS Battle Flow Display showing a trace of the movement of individual vehicles might show platoon vehicles wandering around for many minutes trying to withdraw to an alternate position. A trainer comment like "withdrawal before selecting alternative positions and conducting reconnaissance of routes" for this Battle Flow identifies the tactical event and offers a potential diagnosis of a performance problem.

Another method of enhancing AAR displays was suggested at the first AAR Conference. This suggestion involved giving trainers the capability to draw lines and figures on AAR aids to highlight or supplement key information in the display. This capability is often referred to as the "Madden Pen".

Differences in Data Available Across Training Environments. The data available to prepare AAR aids differ among the training environments. Information about the status of entities, including information about where the gun tube of a tank is pointed at a specific moment, is readily available and accessible

in the virtual environment. In the live environment, update rates on such aspects of entity status as vehicle location are slower than in the virtual world, and some types of information (speed of entities and orientation of gun tubes) are unlikely to be provided in the near future. Similarly, the constructive environment does not play individual entities (except when attempting to link to the other environments in a STOW application).

The UPAS was intended to help integrate performance measurement across the live and virtual environments by patterning the UPAS relational database after the relational tables used for the NTC data archives. Using the exact relational table structure was not considered to be a viable option, because it would preclude the use of data unique to the virtual environment represented by SIMNET. The approach taken was to adopt all of the table and column names from the NTC Archive structure and enhance certain tables with columns containing data unique to the SIMNET environment. Table 2 shows the UPAS Ground Player Location Table indicating the columns unique to SIMNET with an asterisk (*).

A common database structure was adopted under the assumption that software developed to analyze data in one environment could be rapidly ported for use in the other environment. This approach at developing a common database design did not prove useful. The most significant problem was that position location data are reported in different formats between SIMNET and NTC environments, requiring data transformations to put location data into the correct format. ARI was able to examine SIMNET data from one exercise using a utility developed to analyze NTC data, but this required manually transforming position location data.

Table 2.

Contents of the UPAS Ground Player Location Table

- o Time of Vehicle Status Update
- o Player Bumper Number
- o Logical Player Number
- o Position of vehicle expressed in terms of XYZ coordinates
- o Position of Vehicle expressed in terms of XY coordinates relative to the origin of the terrain database*
- o Vehicle speed (in kilometers/hour)*
- o Vehicle azimuth (in MILS)*
- o Gun elevation (in MILS)*
- o Turret azimuth (in MILS)*
- o Engine speed (kilometers/hour)*
- o Odometer reading (in kilometers)*
- o Rounds of ammunition remaining*
- o Fuel remaining (in liters)*

A second major problem becomes apparent if one considers what would be involved in trying to enhance the NTC data to provide the information available in SIMNET. Either a significant investment would have to be made automating the production and communication of data (e.g., to provide information about engine speed), or the information need could be addressed by behavioral observations (e.g., an observer reports significant changes in engine speed for a unit as a whole). The problem with the latter

approach is that it results in a situation where one environment uses qualitative data while another uses quantitative data.

By limiting AAR aids for each echelon to those supported by data elements common to all three environments we are throwing out many of the benefits of electronic battlefields. We might make tradeoffs to retain many of the benefits of standardization without losing the benefits of the unique data offered by each training environment. What we might standardize are a set of unit behavior aspects that are examined in each environment.

For example, an important aspect of the behavior of tank platoons is whether vehicles "shoot and scoot". Using "out the window" or plan view replay capabilities in the virtual environment, a trainer can show cases where vehicles failed to move to alternate positions quickly after firing and, as a result, were damaged by the enemy's returning fire...making a very strong teaching point. A trainer in the live environment might make the same point by asking tank commanders to raise their hands if they were hit by enemy fire, keep their hands up if they were engaging the enemy preceding their receipt of fire, and keep their hands up longer if they had failed to "shoot and scoot". This approach does not provide objective documentation of "shooting and scooting" but it does help to focus attention on critical behaviors.

AAR System Requirements Derived from Force XXI. The Force XXI effort is concerned with leveraging information technology to enhance the capabilities of warfighters, and an important part of the leveraging process is the exploitation of modeling and simulation to support training. One portion of Force XXI involved the use of a survey to identify requirements for an AAR system as a function of such variables as intended application (training feedback versus research) and echelon (Behringer, Brigance, Buckley, Hukill, McDonald, & Sayre, 1995). The capabilities identified in this survey provide additional input for a STAARS ORD. To date, the number of individuals responding to the survey is too small to address all of the information needs the survey was designed to meet.

Early Lessons Learned from the Experimental Force (EXFOR) Program. A distinctive feature of the AAR system developed for the EXFOR program is the attempt to begin addressing the C4I displays being added to tactical vehicles as part of the digitization of the battlefield. In addition to voice communications, digital transmission of data and the display of these data within vehicles must be considered as a unit performance variable.

Summary

The application of data displays to support AARs is a fairly new area, and we have much to learn about the variables determining the utility of specific types of displays. Further, we also need to identify new types of displays that might support the application of standards requiring the integration of electronic, planning, communications, terrain, and behavioral observation data over time.

In addition to selecting types of displays to be included in a STAARS, we are also faced with the tasks of identifying data display and system control features that will meet the needs of users. We know that the capabilities to fast forward during replays, identify players based on bumper numbers, and assess line-of-sight between players are important control features.

Standardizing AAR aids across training environments within echelons helps ensure that AAR aids will be readily interpretable to users, but we must avoid throwing out valuable data that is unique to one or two training environments. One way to make sure aids are readily interpretable without standardization might be to educate exercise participants before training takes place regarding the AAR aids they are likely to see and the functions of these aids.

Recommendations

The list below provides requirements recommended for inclusion in the STAARS ORD. In keeping with the Warfighter XXI philosophy, these requirements describe a needed capability rather than a specific software approach to providing each capability.

- The system must provide the capability to support the implementation of new types of data displays integrating planning data, terrain data, communications data, observational data, and electronic data streams.

- The STAARS should allow users to store and analyze all electronic data produced within any of the three training environments.

- The system must allow the user to navigate through replays by providing the capabilities to "fast forward", move forward or backward directly from one point in time to another, and move forward or back in one second increments.

- The system must allow the user to identify specific entities and units.

- The system should provide navigational assistance for "out the window" displays to keep the user from getting lost.

- The system should allow users to type in comments, draw lines, and draw figures on AAR aids.

- The system should support the storage, retrieval, and display of a library of AAR aids using text, graphics, and figures to describe alternative tactics, techniques, and procedures to support the "a way" concept.

There are a number of research actions that need to be addressed to refine STAARS requirements or support implementation of the STAARS concept. The actions are to:

- examine costs and benefits of alternative operational definitions of the concept of "standardizing AAR aids within echelons";

- define and defend a standard set of AAR aids for a tank platoon or mechanized infantry platoon;

- identify standards or types of standards for which improved data displays are needed;

- o assess factors determining acceptability of display types to various user groups; and
- o examine alternative methods for making sure that AAR aids are readily interpretable.

Tools to Help Trainers Prepare for AARs

Background

An AAR system should help ensure that displays are ready to support AARs as soon as possible after the end of an exercise (ENDEX). This is especially true for AARs conducted for lower echelons, because the results of lower echelon AARs provide input for the later conduct of higher echelon AARs. In the Fort Knox Mounted Warfare Training Simulation Center (MWTSC), for example, the goal is to begin conducting platoon-level AARs ten minutes after ENDEX.

The job of preparing to conduct AARs includes deciding what teaching/training points need to be made, deciding what AAR aids can be used to help illustrate points, developing questions to be used in guiding unit discussions during the AAR, and creating AAR aids. This work must also be coordinated with the exercise management and control functions of trainers to ensure, for example, that AAR preparation does not distract a trainer from exercise control activities.

STAARS and DIS Standards Guidance

The STAARS MNS does not specify the functions a STAARS should perform to help a trainer prepare for AARS, but it does provide information that must be considered when developing requirements for a STAARS system and when selecting a materiel solution to the STAARS requirements. The STAARS must avoid duplication in the development of software to support the preparation of data displays. The STAARS must work in a manner that will not disrupt exercises. Finally, the system must be applicable across training environments. The DIS Standards guidance does not address what a system should do to help users prepare for AARs.

History and Status of Research

Historical Perspective. One of the key concerns driving development of the UPAS was the shortage of tools to support AARs in the SIMNET training environment (Goldberg & Meliza, 1993). These tools included one Plan View display and one Stealth (out-the-window) view in situations where as many a five exercises might be conducted concurrently. These sites did not support the

capability to provide statistical summaries such as the number of rounds fired by each crew in a platoon.

By adopting a personal computer (PC) as the hardware platform, we gained the capability to distribute AAR systems down to platoon level at a low cost. However, in comparison with work stations, we lost speed and multi-tasking capabilities. One of the major problems encountered in applying the UPAS as an AAR tool was that it took too much time to prepare AAR aids (Shlechter et al., 1994; Meliza, Bessemer, & Tan, 1994). For platoon exercises, trainers want to start AARs within about ten minutes after ENDEX. Due to the fact that UPAS is a PC-based system, it could only perform one function at a time. During exercises, UPAS was fully occupied with network data collection and could not be used to support exercise monitoring or AAR aid preparation. After data collection, a substantial amount of time was required to generate a second by second index file of network data and load network data into a relational database to support preparation of graphs and tables. The time required to generate index files and load data tables often exceeded ten minutes.

Another problem with using UPAS as an AAR system was that it left the job of selecting and preparing AAR aids up to trainers. The work left up to trainers included: assessing the major unit strengths and weaknesses; selecting the types of displays to use in illustrating outcomes and guiding a unit towards diagnosing their own strengths and weaknesses; selecting appropriate display parameters (e.g., time, area, level of magnification); and developing questions or comments to be used with each display.

The move to workstations reduced the time required to perform certain AAR preparation tasks and provided the opportunity to add tools for helping trainers to prepare AAR aids. UPAS data displays have been ported to work stations in two separate efforts to address the problems we discovered in UPAS usage. At roughly the same time, other workstation-based AAR systems were also being developed to support AARs in the virtual and constructive environments.

STRICOM funded an effort by Loral Advanced Distributed Simulation to port UPAS data displays and functions to a Silicon Graphics workstation. This effort was performed by integrating UPAS displays with existing DIS Tools software that included two

dimensional and "out the window" views of the battlefield. STRIPES can be used to monitor an exercise from a plan view and/or "out the window" view at the same time that exercise data are being collected. Due to the fact that STRIPES runs on a workstation, the time to load the relational database is greatly reduced. However, as in the case of UPAS, the job of preparing an AAR begins at ENDEX.

Automated and Semi-automated Generation of AAR Aids.

Lockheed Martin demonstrated a system at the second AAR conference that automated production of AAR aids. This system employed a workstation to collect exercise data. At ENDEX, a software routine is used to load AAR aids to a floppy file for delivery on a PC. The beginning and end points of the time covered by each aid was decided by automated analysis of the network data stream to identify when certain tactical events occurred (e.g., the time of the first friendly direct fire). The data displays included tables, graphs, and short animated plan views. Further, the system allowed the trainer to include other types of AAR aids, such as TTPs from "how to fight" manuals.

LB&M Associates developed the Automated Training Analysis and Feedback System (ATAFS) to help trainers prepare and conduct AARs by addressing problems identified in using UPAS (Brown, et al., 1995). ATAFS uses a knowledge database to guide the preparation of AARs aids automatically. In addition, ATAFS allows users to move back in exercise history and create AAR aids manually as the system continues to collect exercise data. The result of these two enhancements is to provide an AAR Bin with automatically and manually generated AAR aids at ENDEX.

The automated production of AAR aids in ATAFS is guided by a knowledge database. To create a particular aid, a system needs to know the time to be covered by the aid (e.g., from 14:33:00 until 14:35:15). These points in time are dependent upon when tactical events occur. The developers of ATAFS realized that the occurrence of some of these events could be measured automatically by an AAR system through analysis of the network data stream. The time of other events is better identified by having a human look for and report the occurrence of these events (e.g., a platoon leader issues an order). ATAFS creates aids using a mix of data stream analysis combined with operator

response to prompts made up of a list of tactical events which the trainer is expected to observe. Figure 5 illustrates the screen a trainer uses when monitoring an exercise.

Another way in which the ATAFS helps trainers prepare timely AARs is to allow users to move back in exercise history and create aids manually as the ATAFS continues to collect data. The VCR-like controls at the upper left corner of the ATAFS screen can be used to move back in history, or return to real time, as the ATAFS continues to collect data. If the user wants to create an aid, he or she selects one of the buttons at the upper right hand portion of the screen, such as "Plan View". The user then selects the button once to indicate the time when a Plan View should begin and a second time to indicate when it should end. At ENDEX, the trainer can go to the ATAFS AAR Aid Bin and review the aids that have been automatically and manually created. Each of the automatically generated aids includes a list of discussion

questions that might be used by the trainer to help insure the AAR discussion process will lead towards an explanation for the unit's performance (see Figure 6).

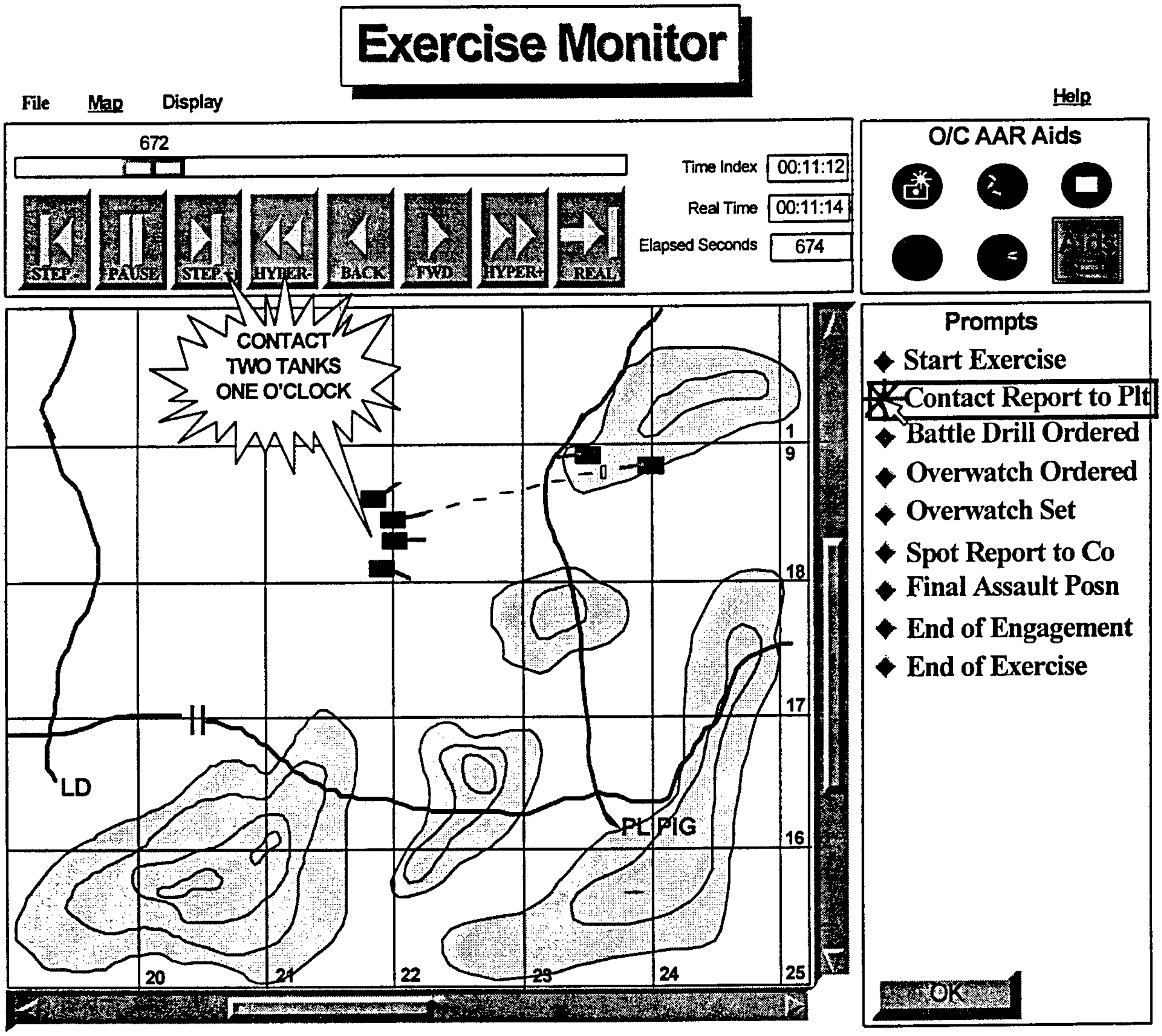

Figure 5. Sample exercise monitor screen for the ATAFS. (Copyrighted material reproduced with permission of LB&M Associates.)

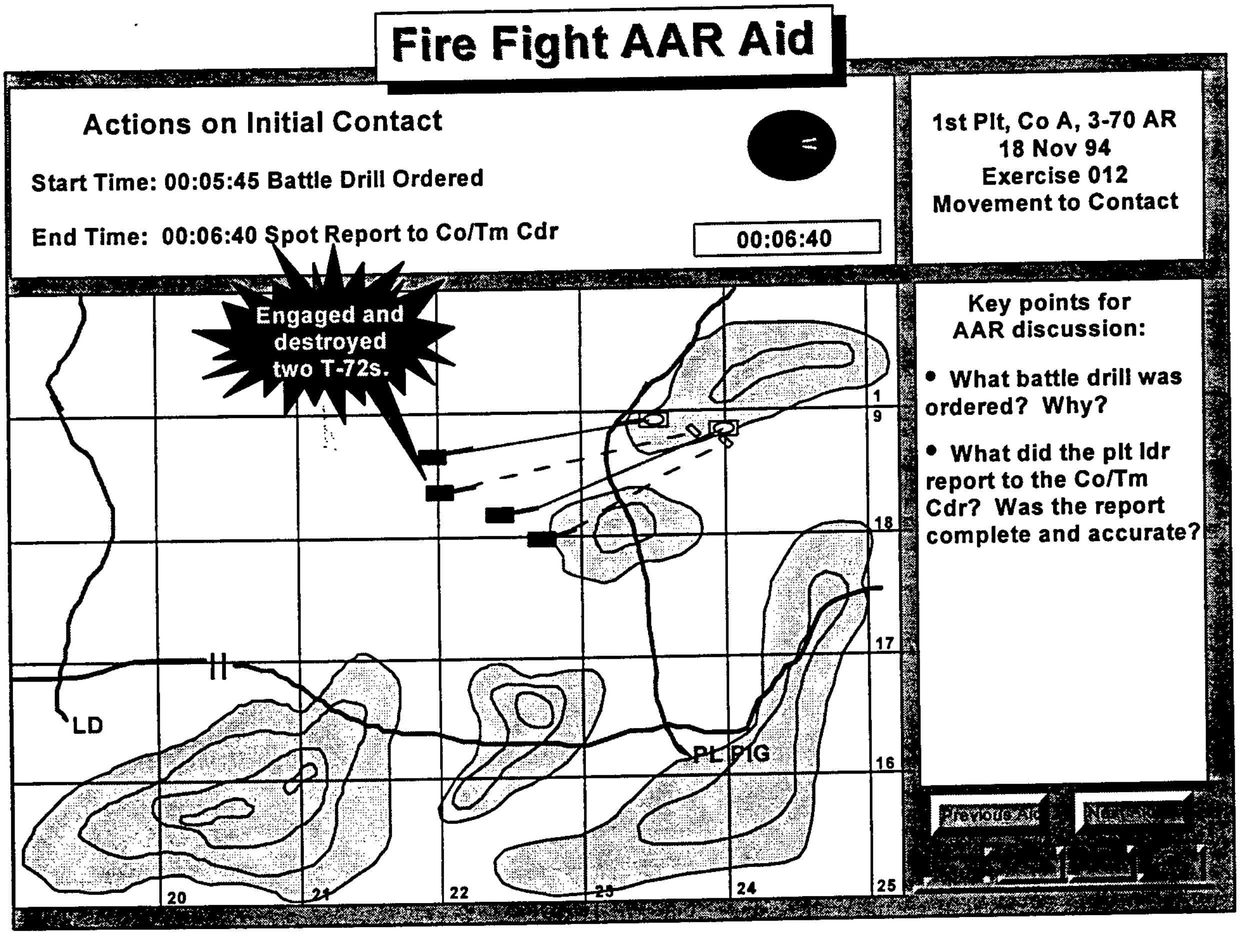

Figure 6. Sample ATAFS AAR aid showing discussion points. (Copyrighted material reproduced with permission of LB&M Associates.)

Editing AAR Aids. The ATAFS system allows trainers to perform two types of editing functions. First, trainers can add or modify discussion questions or comments at the right hand side of each aid, and they can name or rename the tile of the aid or the tactical events defining the aid. Second, trainers can modify the period of time covered by an aid. This latter capability is useful if the original time period leads to a situation where part of a radio communication is cut off and the trainer wants to expand the time covered to include the entire communication. The latter capability is also useful when an

unexpected critical tactical event occurs that a trainer wants to include in the aid.

It is important to point out that the ATAFS creates definitions of AAR aids rather than AAR aids per se. That is, aids are defined by time and any changes the user makes to the standardized list of discussion points or labels. From the perspective of the user it appears that the entire aid is saved, because the aid appears on screen so fast after it is selected.

Saving AAR Aids. Earlier versions of the ATAFS failed to save the definitions of AAR aids that had been automatically or manually created when the user exited the exercise database. The capability to save the definitions of AAR aids within the exercise database was not considered to be necessary, because these aids can be saved by downloading them to a VCR tape. The most serious consequence of failing to save AAR aids in the exercise database is that all of the aids are lost if the system "crashes" before the AAR is conducted.

Failure to save the definitions of AAR aids also reduced the utility of ATAFS as an AAR research tool. Saving of the definitions allows researchers to examine exercise databases to answer such questions as: to what extent do users supplement automatically generated aids with manually created aids? What portion of the aids are actually used for AAR?

Giving the User the Ability to Automate AAR Aid Production. The ATAFS project includes the development of an authoring tool (ATAFS-AT) to allow non-programmers to modify the sets of aids created automatically for a mission and/or automate AAR aid production for additional missions (Brown, et al., 1995). Figures 7 and 8 help to illustrate how this tool will work. To automate the production of an aid, the user must identify the type of aid, the type of tactical events triggering the beginning and ending of the time covered by an aid (unit crossing of a line, unit entering an area, a firing event, a battle damage event, or an event that must be identified by a trainer through response to a screen prompt), the name of the aid, a description of the triggering events, and discussion points.

After selecting icons representing trigger types, users select the specific parameters. For example, if the icon for

crossing a line is selected, the user must select first vehicle, last vehicle, or center of mass of platoon to define the criteria ATAFS will use in deciding when the line has been crossed. The user must also select among a group of options to identify the type of line to be crossed, such as the Line of Departure, a phase line, or a boundary. If the trigger is a screen prompt the user may select an existing prompt or create a new one.

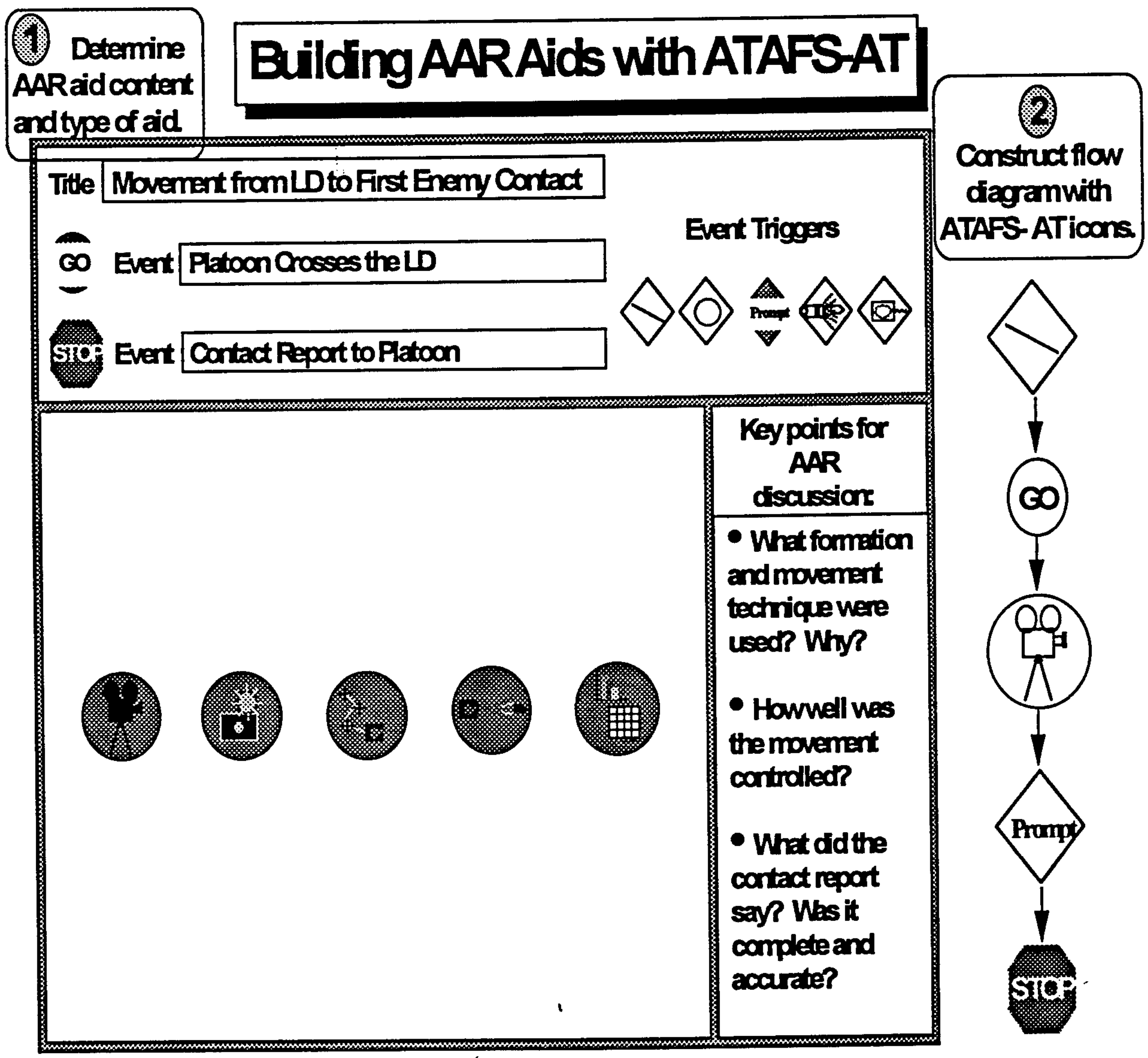

Figure 7. Creating or modifying an automated AAR aid through icon selection. (Copyrighted material reproduced with permission of LB&M Associates.)

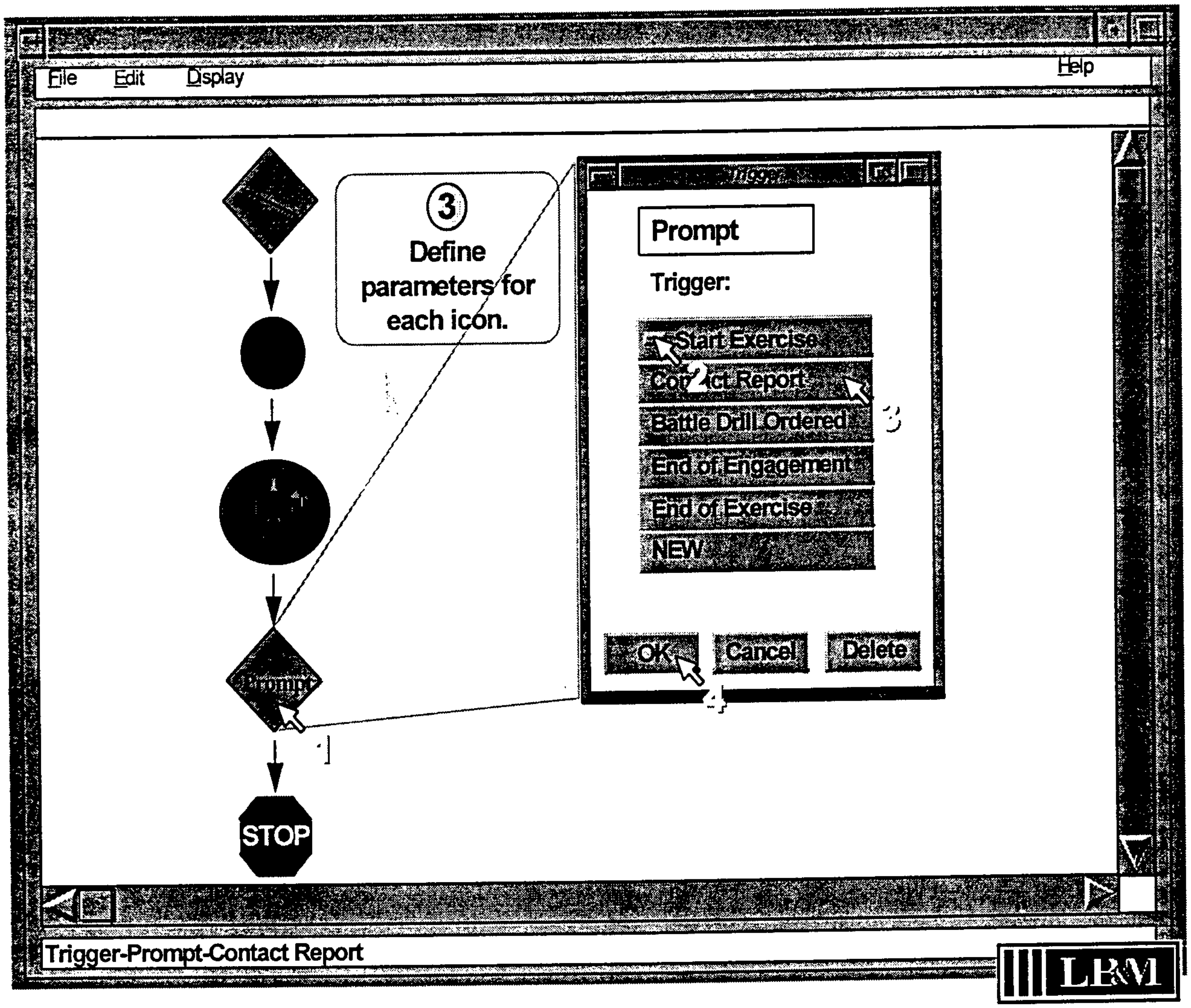

Figure 8. Creating or modifying an automated AAR aid by defining icon parameters. (Copyrighted material reproduced with permission of LB&M Associates.)

<u>Linking AAR Aids to Exercise Outcomes</u>. Automated support of AAR aid preparation should go beyond providing a standardized set of data displays for specific collective tasks. Participants in the first AAR Conference noted the need for tailoring AAR aids to fit the outcome of exercises (Goldberg, 1994). While the occurrence or non-occurrence of certain tactical events influences the set of candidate AAR aids produced for an exercise by the ATAFS knowledge database, this does not guarantee that

every aid will be useful. ATAFS might produce eighteen AAR aids, but usually only three or four of these are needed to help make the points the trainer wants to make. Additional tools are required to help trainers select among candidate AAR aids.

Focusing on Specific Behaviors. There are a large number of performance standards that might be applied to a unit during exercises. In many cases, limitations in the time available to conduct an AAR preclude providing a unit with feedback on how it performed with respect to every standard. Another function of an AAR system should be to help a trainer focus on selected aspects of unit performance.

For battalion task force level AARs at the NTC, a strategy is employed to help focus the AAR on specific aspects of unit performance. That strategy involves focusing on aspects of unit behavior that contributed directly to the outcome of a mission (Meliza, Sulzen, Atwood, & Zimmerman, 1987). This approach is expected to help motivate units to take corrective actions by demonstrating the importance of the deficiency to unit success. This link provides a stronger motivation than pointing out that the performance of the unit was not in accordance with Army doctrine.

Another approach to focusing on selected aspects of performance is to consider errors which tend to show up across a large number of units. For example, if it were found to be the case that armor and infantry platoons frequently move in the immediate vicinity of friendly vehicles or units that have just been successfully engaged by the enemy, this would be an aspect of behavior that a trainer should be prepared to check.

Integrating the AAR Preparation System with Exercise Planning and Control Systems. The job of preparing to conduct an AAR is tied to the exercise planning and control systems. When highly structured scenarios are employed, a trainer can better anticipate when key exercise events will occur and use AAR aids to focus on these events. When highly unstructured scenarios are employed, trainers are at a distinct disadvantage in terms of AAR preparation.

In most cases a trainer serves both exercise control and AAR preparation functions during exercises. Exercise control

functions include acting as the higher headquarters to the unit, monitoring actions to make sure the tactical situation supports the training objective, and intervening in the tactical situation to help insure the exercise provides an effective training opportunity. To the extent that the AAR system and exercise control system compete for the attention of the trainer, AARs and exercise control suffer.

Two examples of the lack of integration between AAR and exercise control systems can be provided based upon experiences within the Fort Knox, KY, Reserve Component Virtual Training Program (RCVTP). First, the UPAS was added to the RCVTP in a situation where the exercise control system was composed of a modular semi-automated force (ModSAF) work station for controlling the behavior of enemy and friendly computer generated forces and emulating supporting fires. In this situation, a ModSAF Plan View and an "out the window" view were available to help monitor unit performance. Two individuals were involved in the conduct of training; one to control the ModSAF during exercises and the AAR displays during the exercise, and a second to serve as the trainer. An immediate problem was that the time-consuming job of loading control measure graphics data had to performed separately for ModSAF and UPAS. Having the capability to load graphics into one system and then copy the resulting data into the other would improve training efficiency. It should not be too surprising in this case that the RCVTP trainers used the same tools they employed in monitoring exercises (the ModSAF plan view and "out the window" view) to provide AAR aids rather than trying to support a second system.

The second example of an integration problem involves competition during exercises between the ATAFS AAR system and the exercise control system described above. The UPAS did not compete with exercise control during exercises for the simple reason that all the UPAS can do at that time is collect data. ATAFS helps trainers to begin preparing AARs during exercises, increasing the potential for conflicts between the exercise control and AAR systems. To employ the semi-automatically generated ATAFS AAR aids, trainers must respond to screen prompts, and use of the prompts requires monitoring the radio net. The result is to add a third monitor that can be used to observe the exercise and a second set of speakers providing radio communications. In an ideal world, the ModSAF operator would use

the ModSAF workstation, and the trainer would use the ATAFS to monitor the exercise; however, the radio communications over the ATAFS (and all movement and firing events displays on the ATAFS screen) are roughly two to three seconds behind real time due to the fact that ATAFS processes data before it is displayed. The delay has no effect on AAR aid preparation, but it makes it difficult to use ATAFS radio communications as part of the exercise control loop. A second problem is that trainers want to use the "out the window" view for both exercise control and AAR functions, causing the trainer to have to interact with two workstations during AARs.

STRICOM is aware of the need to integrate the various workstations used in the DIS environment (Watson & Schow, 1995; Butler & Wiehagen, 1995). Further, STRICOM is preparing to initiate an effort to develop a testbed for integrating system components.

Training Users of a STAARS. Given the reductions in military funding it is unlikely that every site where AAR systems are employed will have personnel permanently assigned to O/C duties. Instead, the trainer conducting the AAR will often be from the unit being trained, and the unit might have limited access to AAR system hardware and software. For example, a National Guard Unit might have access to a mobile SIMNET system once or twice a year over weekends. Fielding an AAR system that can be used without substantial hands-on practice is a major challenge.

The Defense Advanced Research Projects Agency (DARPA) Simulation in Training for Advanced Readiness (SIMITAR) Program has taken a major step in addressing this challenge by funding the development of a computer-based training (CBT) program for users of the ATAFS combined with trial fielding the CBT and ATAFS system at a variety of Army National Guard (ARNG) training sites. These sites include mobile SIMNETs in the Northwest and Southeast as well as fixed sites. The fixed sites include ARNG armories and the MWTSC at Fort Knox, KY.' The extent to which individuals conducting AARs will have the opportunity to gain experience using an AAR system increases going from mobile SIMNETs to armories to the MWSTSC. System fielding at these diverse sites provides a testbed for addressing many research issues concerning preparation of trainers to employ AAR systems.

The formal program of instruction for ATAFS users includes approximately two hours of CBT delivered on a multi-media personal computer combined with two hours of hands-on practice in which members of a two-person team alternate taking the roles of operator and informal assistant. Training is conducted in this manner because the members of the team help to coach each other. The hands-on session involve the replay of network and radio communications data from a previous exercise in a manner that simulates realtime data collection.

ATAFS installation and user training have been conducted at four sites, and participants were confident of their ability to use the system after an hour or less of hands-on training. There have been problems with user interactions due in large part to the fact that few trainers are familiar with critical differences between PCs and workstations. Additional software is required to help trainers perform certain routine functions on the work station, such as deleting exercise directories.

Summary

Moving from a PC to a workstation environment enables speed and multi-tasking capabilities to reduce the time required to prepare AAR aids. Additional reductions in time, and support of the trainer's decision making process, have been gained by automating the preparation of AAR aids. The completely automated approach relies on software analysis of the network data stream, while the semi-automated approach uses trainer reactions to on screen prompts to identify when tactical events occur that are not part of the network data stream (e.g., when a platoon reports contact to the company commander).

Additional work is required if the AAR system is to provide trainers with further assistance by helping consider how exercise outcomes influence the utility of candidate AAR aids. We have gone beyond the point of creating a fixed set of aids for a particular collective task to the point of tailoring the output of aids to fit the tactical events that actually occur in a specific instance of task performance. We need to go a little further and help the trainer select among these candidate aids.

As we attempt to help trainers prepare AAR aids, we must consider the need to integrate the AAR system with the exercise planning and control systems. We want an AAR system to help a trainer monitor and control the execution of an exercise rather than distracting trainers from these duties. STRICOM is initiating a testbed concerned with integrating various training system components in the DIS environment, and integration of exercise control and AAR functions should be a key part of this effort.

Training users to employ an AAR system is a concern, because time and other resources required to conduct this training are severely constrained. LB&M Associates has developed a CBT program for the ATAFS that appears to prepare most trainers to employ this system to create automated and manual aids after two hours of CBT followed by an hour or so of hands-on practice with the actual system. The availability of this training system in a variety of training environments enables research on training personnel to employ AAR systems.

Recommendations

Items that might be included in a STAARS ORD are listed below.

- o The system should increase rather than reduce a trainer's capability to perform exercise control functions during exercises.

- o The system should automate the production of candidate AAR aids and allow the trainer to select those he/she considers to be relevant to a specific exercise.

- o The system should give the trainer the capability to supplement automatically produced aids with manually generated aids.

- o The system should help the user select among candidate AAR aids, in cases where users want such help.

- o The system should allow the user to store AAR aids or definitions of AAR aids.

- o The system should allow the user to modify the time period covered by each aid.

There are a number of research and development issues that need to be addressed to support the design and implementation of AAR systems that can provide high quality AAR aids without requiring excessive inputs from trainers. Research and development needs are listed below.

- o Develop methods for selecting AAR aids that fit specific exercise outcomes.
- o Develop strategies for focusing on specific behaviors during exercises and test the comparative utility and user acceptance of the strategies.
- o Use ATAFS as a test case for assessing the amount of CBT and hands-on training required to prepare leaders to employ an AAR system.

Creating a User Friendly AAR System

Background

Systems that are inflexible or lack internal consistency in terms of procedures frustrate users. If the system will not support the activity a user wants to perform, then the user will often have to complain to the software developer and wait for the next version of the software to employ the desired capability. If the system lacks internal consistency in terms of the way information is presented or the way a user is expected to provide input, then it will be difficult to complete initial and sustainment training on the system, and the error rate will often remain too high.

As mentioned earlier in this report, we have limited experience using AAR aids to support AARs and we can expect the process of learning lessons about AAR tools to continue over the next few years. We want to avoid specifying the exact design features of STAARS data collection, analysis, and AAR preparation tools too early in a manner that will prevent users from modifying tools in response to lessons learned.

STAARS and DIS Standards Guidance

According to the STAARS MNS, STAARS will provide standardized user definable products incorporating playback capability, C4I/video products, access to doctrinal resources, statistical products, terrain analysis, and trainer observations. The expression "user definable" indicates that providing users with the capability to create and modify AAR aids is a high priority. Further, STAARS must be flexible enough to fit the constructive, live, and virtual environments. Creating software that allows users to create and modify AAR aids without going back to the software developer to reprogram the system is also supportive of the general Warfighter XXI goal of reducing software development costs by avoiding duplication.

The draft DIS Standard concerning exercise management and feedback promotes flexibility by identifying capabilities that have user selectable features (Institute for Simulation and Training, 1995). Examples include selection of PDUs to be

collected, selection of features to be displayed in plan view displays, and the capability to customize graphs, tables, and timelines.

History and Status of Research

System Flexibility. One of the most important lessons learned during refinement of UPAS software is that the user must be provided with the capability to control the contents of data displays. Most of the revisions made in UPAS software were made in order to provide the user with greater flexibility to control AAR displays (Meliza, Bessemer, and Tan, 1994). This same lesson was relearned in the development of the STRIPES and ATAFS workstations. To the extent that users can modify data displays without the assistance of a programmer, the system is considered flexible.

The early prototype of the UPAS was developed with the knowledge that trainers and researchers could not specify the data summary graphs and tables they would need. Therefore, the UPAS includes editors that allow non-programmers to add or modify graphs and tables. This makes it possible to revise the displays in response to user feedback or in preparation for applying the system to a new training or research objective. Neither the STRIPES nor the ATAFS, in their initial versions, allowed users to add or modify graphs and tables without the aid of programmers.

At the third AAR Conference, representatives of the United Kingdom Center for Defence Analysis described data summary graph and table requirements to support SIMNET training in the near term and training with the United Kingdom CATT in the longer term. The variety of displays goes beyond what is currently available in STRIPES, ATAFS, and the CCTT AAR system. A near term solution to this problem is being tested by modifying STRIPES to download data to a PC during exercises. Once these data are on a PC, then a wide variety of commercial off-the-shelf (COTS) software can be used to create essentially any type of data table or graph the user may want.

A flexibility problem has also been encountered in the design of an ATAFS-AT to allow users to create or modify the AAR aids to be generated automatically during exercises. In cases where the

triggering event is one which requires analysis of network data, the user is limited to using trigger types and parameters for which a programmer has already written data analysis routines. A potential solution to this problem would be to provide a tool that allows non-programmers to collect and manipulate the data stream during exercises. McDonough and Herman (1995) recently suggested implementing such a capability for STRIPES.

The flexibility problem often shows up in unexpected ways. To help illustrate the breadth of the flexibility problem, a list of examples is provided below.

- During one of the early applications of the initial UPAS Firefight Display, data were collected from an exercise in which a heavy volume of fire was provided by a weapon firing 25mm rounds. Shotlines for the 25mm firing events tended to dominate the displays and obscured tank firing events. To fix this problem, the software was revised to allow users to employ sampling plans to reduce the shotlines for the 25 mm (e.g., showing shotlines for every third round).

- The capability of the ATAFS to generate AAR aids automatically was tested in a situation where the platoon was a six vehicle scout platoon rather than a four vehicle armor or mechanized infantry platoon. The algorithm used by the ATAFS to assess various states (i.e., when control measures are crossed) assumes a four vehicle platoon and will not work with other values. There was a historical precedent for this flaw in that the UPAS was designed to allow the user to load vehicle IDs in a manner that informed the system which of a maximum of four vehicles belonged to each platoon. This limitation became a problem the first time UPAS was applied to scout platoons.

- To expedite the preparation of data tables and graphs, the UPAS extracts data from network data packets for loading a relational database management system. The UPAS data tables were patterned after the NTC archives database to support common analyses of SIMNET and NTC data and thus certain types of data unique to SIMNET were not loaded into the database. For example, there is a fire packet and impact packet generated for each direct round fired in

SIMNET, and each of these packets contains a firing event number. Firing event numbers are generated sequentially for each entity, and the same event number is used for the fire and corresponding impact packet. Although most of the information in fire and impact packets were loaded into the UPAS relational database, data on the event number was viewed as having no value and not included. Subsequently we found that these data were often critical in sorting out the effects of weapon systems during exercises, and the UPAS software had to be revised to load these data into the relational database. Until this change was accomplished, it was necessary for researchers to go through the extremely tedious process of examining thousands of data packets using a UPAS packet reader to obtain information about firing event numbers.

- Not all lessons learned involve bad news. An unexpected benefit of using a relational database combined with an editing system to support data graph and table preparation is that it allows one to integrate new types of information into data displays without formal reprogramming of software. For example, a communications data table was added to the UPAS by non-programmers after the software for loading the database and editing graphs/tables was developed. The data in this new table could then be included in the creation of new data tables and graphs.

Bessemer (1996) spoke at the 3rd AAR Conference on the need for system flexibility and made a good case for an additional expansion of the flexibility concept to include the capability of a system to capitalize on future circumstances and technical advances. Future circumstances include the development of training support packages, the planned digitization of the battlefield, and the fielding of new weapon systems. Technical advances might include the development of intelligent databases to aid in data analysis and evolving exercise control systems (e.g, ModSAF).

Internal Consistency.

Specifying a particular graphical user interface (GUI) is merely one of the tasks necessary to ensure that users of a system will not be frustrated by what appear to be inconsistent

procedures. Prior to the start of coding, it is critical that a plan be developed that specifies and standardizes the way information will be presented to the user and the ways in which the user must respond to the system. The plan must include provisions for ensuring that the specifications are being followed and that they are resulting in a product that is acceptable to the user. Testing the product at various stages of development may lead to the finding that sections of the procedures need to be modified to create a better product.

We must also consider that the need to provide a standardized interface includes other software that the trainer might use in association with the AAR system. That is, the same standard should apply to exercise planning and control systems and to any CBT programs used to prepare trainers for employing AAR, exercise planning, and exercise control systems.

The STRIPES system provides an example of how the exercise control and AAR systems can be modified to enhance internal consistency and reduce operator training requirements. The plan view display in STRIPES was replaced with that used in ModSAF. All the tools previously available to trainers when using ModSAF (e.g., the capability to call up line-of-sight displays) are now available during the AAR, and the same procedures are used to call up these capabilities during exercises and during AARs.

Rosmarin (1996) pointed out an important interaction between the need for system flexibility and that for internal consistency. A commonly used approach to gaining flexibility is to use a mixture of COTS software, but this approach can produce an overall product in which key features of the user interface change as the user goes from one program to another. Rosmarin pointed out the need for developing a shell around a mix of COTS software to provide a consistent interface.

Summary

User frustration with an AAR system will increase to the extent that the user cannot control the collection, storage, analysis, and display of data. Frustration levels will also increase to the extent that methods for presenting information and methods for controlling the system differ across system functions or among related software systems.

Recommendations

Items that would enhance the flexibility of the STAARS recommended for inclusion in the ORD are listed below.

- o STAARS must allow users to create and modify data summary graph and table options.
- o STAARS must allow users to integrate observational data with electronic data.
- o STAARS must provide the user with the capability to examine all data from the network data stream in a format that supports rapid analyses (e.g.,by loading all network data into a relational database management system).
- o STAARS must offer flexibility in terms of unit structures and the pairing of individual entities with units.
- o STAARS must allow users a reasonable degree of control over whether and how terrain, planning, communications, and network data are displayed.

Items that help to ensure internal consistency in terms of the human/machine interface are listed below.

- o The STAARS human/machine interface must be internally consistent in terms of the manner in which information is presented to the user and the manner in which the user is required to respond to the system.
- o The STAARS human/machine interface must be consistent with the interfaces of software systems used in association with STAARS (CBT for users of STAARS and integrated exercise planning and control systems).
- o The STAARS human/machine interface must be developed according to a plan encompassing continual testing of adherence to standards, early user acceptance testing of interface components, and refinements of standards to improve user acceptance.

The suggestions regarding statements that might be included in the STAARS ORD to help ensure system flexibility are presented in reaction to specific problems that have been encountered repeatedly. We need a more proactive approach to ensuring system flexibility. This might be accomplished by developing more general standards for system flexibility and/or by developing procedures for early identification of potential problems for specific applications. Cubic Corporation's effort to attain a high degree of flexibility for the Vision XXI AAR system for constructive simulations by using a minimum of system-unique software and a maximum of COTS software is an example of an innovative attempt to develop a more general standard for flexibility (Huff, 1996). Employing task analysis procedures to identify potential flexibility issues concerning the integration of AAR systems with exercise planning systems might make a good test bed for developing procedures for the early identification of flexibility problems.

Preparation of Take Home Packages

Background

The Take Home Package (THP) concept involves providing units with performance information that they can review after an intensive period of training to help define future training strategies. The THP can play at least three roles. First, it can reinforce lessons learned during AARs for individual exercises. Second, it can be used to provide feedback regarding aspects of performance that were important but not addressed during AARs. Third, the THP can be used to present information on trends in performance across exercises. These trends might indicate a persistent problem in performance (e.g., the earliest the platoon reported contact to the company commander was twenty minutes after first contact) or an improvement in performance (e.g., the number of crews boresighting their weapons prior to the start of the exercise increased from ten percent to fifty percent to ninety percent). In order to support this last application there is a need to store data in a form that supports the analysis of trends across exercises.

STAARS and DIS Standards Guidance

THPs and THP preparation are not addressed in the STAARS MNS. Instead, the THP role appears to be replaced by the input that STAARS provides to the SATS Component of Warfighter XXI. THPs are not addressed by the draft DIS standard for exercise management and feedback (Institute for Simulation and Training, 1994).

History and Status of Research

Variables Affecting the Utility of THPS. The NTC THP is a mixed media package that includes written descriptions of unit performance and videotapes of AAR sessions. The NTC THP makes use of written descriptions of individual exercises organized by battlefield operating systems. These written materials also include descriptions of performance trends and recommendations for improving performance.

Units typically find it difficult to make use of these materials due to personnel turnover after rotations to the NTC and due to the amount of time required to analyze these data (Fobes & Meliza, 1989). One would expect that units participating in virtual exercises, constructive exercises, and live exercises at home stations to be in a better position to make use of the THP concept, because personnel turnover should be less of a problem.

In talking with unit leaders about if and how various components of the NTC THP were used, Fobes and Meliza (1989) found that VCR tapes of AAR sessions were borrowed for review by units preparing to go to the NTC. These tapes were considered to be a training medium in their own right.

The personnel resources required to prepare NTC THPs go beyond those available in many training situations. A number of efforts have worked toward the development of electronic THPs to help reduce the time and effort required to prepare these products. The intent of these efforts is to provide THPs on media that are readily available to units, such as VCR tape players and personal computers.

The ATAFS loads AAR displays to VCR tape. The trainer may load only the displays used for an AAR, or he/she may add additional displays not used during the AAR. The trainer may also choose to load the entire exercise to VCR tape. A drawback in this approach is that it does not provide information about what exercise participants said during the AAR. Information about what the unit identified as the source of unit strengths and weaknesses and corrective actions are not included in the THP.

The electronic THP concept might be modified to include information about the causes of strengths and weaknesses and corrective actions. One approach is to tape AAR sessions. Another approach might be for a trainer to summarize the outcomes of the AAR in an electronic format using brief statements or responses to a checklist of items.

The CATT Training Exercise Development System (CATT-TREDS) project includes the collection of data on unit performance at the MTP subtask standard level and the application of these data

in planning future exercises. CATT-TREDS is being tried out within a number of units, and this project should provide us with information regarding the feasibility of collecting detailed unit performance evaluations on a regular basis.

There are many questions about the intended use of THPs that need to be addressed before we can specify the requirements for a STAARS. At least a portion of these questions need to be addressed by representatives of the SATS component of Warfighter XXI regarding the information needs of SATS. For example, should a THP address each separate exercise, only the last exercise of a particular type, and/or trends in performance across exercises?

The THP Preparation Process. The work involved in preparing a THP can be illustrated by considering what O/Cs at the Fort Knox VTP do to prepare THPs. Again, remember that one of the reasons for preparing THPs is that not enough time is available during AARs to cover every critical aspect of unit performance.

During exercises, O/Cs attempt to complete a form containing relevant performance standards from MTP documents. The RCVTP THP is expected to including ratings on these standards and to give greater weight to ratings given later rather than earlier in training a specific MTP task. Along with these ratings, the O/Cs provide narrative descriptions that may explain ratings and/or provide guidance for improving performance in the future. This guidance might involve references to doctrinal literature or other types of guidance falling under the "a way" concept.

Making it Easier to Relate Performance Outcomes to Corrective Actions. The large number of MTP performance standards that might be applied to exercises reduces the possibility that a thorough rating of a unit on every standard will be provided as input to the SATS components of Warfighter XXI. For example, the MTP for a Battalion Task Force covers 1,489 subtask standards distributed among 343 subtasks. A general approach to reducing the data collection load is to provide ratings of unit performance at levels higher than the subtask standard level. For example, observer/controllers within the Reserve Component Virtual Training Program at Fort Knox, KY, rate units at the subtask level in terms of whether they need to "train to improve" versus "train to sustain" on specific subtasks (Shlechter, et al., 1995).

Another approach to using a mission structure that provides a more succinct description of unit performance is the use of critical combat functions (CCFs). CCFs are higher than task level but lower than the battlefield operating system (BOS) level (BDM, in preparation). Another similar approach taken under STRICOM's Advanced Distributed Simulation Technology contract with Loral Advanced Distributed Simulation is the development of a Training Architecture Database in which MTP tasks are referenced to functional areas under the BOS framework.

A fourth approach to reducing the data load for satisfying SATS requirements is to summarize data in terms of performance trends for a particular unit. For example, if a unit repeatedly fails to execute a combat task across missions, or repeatedly has problems in performing the same type of activity within a mission (a unit fails to communicate with sister units during each phase of a mission), then this information would have a high payoff for inputting into the SATS.

Summary

The need for THPs after virtual training exercises may be greater than that for capstone training events like an NTC rotation for the simple reason that units are more likely to have an opportunity to take advantage of the information provided. It must also be considered that we are moving into a new era where a portion of the information provided in THPs might need to be provided in a format that can be used by an automated training management system like SATS.

In addition to providing a THP product that supports SATS, there are other goals to keep in mind when considering the requirements for THP preparation. We need to move away from paper-based THPS toward electronic THPs. We also need to make it easier for the preparers of THPs to relate performance outcomes to corrective actions. Addressing this latter goal involves exploring the application of task structures and techniques (e.g., looking for repeating patterns) that make it easier to organize and summarize feedback.

Recommendations

The STAARS should be capable of changing the task structure used to support assessments of unit performance (e.g., MTP structure versus CCF structure) without reprogramming of software.

Research/development issues that need to be addressed are listed below.

- o We need to find out whether there are benefits to providing a THP separate from those gained by loading unit performance evaluations into a SATS.

- o We need to know how to use STAARS to support SATS functions without imposing a heavy burden on the shoulders of trainers by finding out the minimum type and level of data input required to support effective training strategy development.

Providing Input for the Army Training Digital Library

Background

The intent of changes in doctrine, training, leader development, organization, materiel, and soldier systems (DTLOMS) is to improve performance on unit collective tasks. Data from collective training exercises might make significant contributions to Research Development and Acquisition (RDA)and Advanced Concepts and Requirements (ACR) efforts.

STAARS and DIS Standards Guidance

The STAARS MNS specifies that "STAARS standardizes the automated storage, distribution, and retrieval of AAR data within the ATDL architecture." The MNS also specifies that STAARS will provide information through the ATDL to: the training, exercises and military operations (TEMO) community; the research, development, and acquisition (RDA) community; and the advanced concepts and requirements (ACR) community.

The draft standard for exercise management and feedback does not specifically address the issue of archiving exercise data for research purposes (Institute for Simulation and Training, 1994); however, certain capabilities noted in the draft are relevant to archiving for research applications. Namely, the data should be archived in a manner that allows reproduction of the data stream exactly as received and supports analysis across exercises.

History and Status of Research

Non-attribution. A major concern expressed during the second AAR conference was protecting the identity of units when their performance data are loaded into a research database like the ATDL. The developers of STAARS and the ATDL must jointly decide whether unit IDs are to be removed before data are made available to researchers, or if researchers are to be made responsible for maintaining confidentiality.

Protection of unit identities has long been a policy of ARI and the TRADOC Center for Lessons Learned (CALL) regarding the analysis of data from unit rotations to CTCs. In this case, unit IDs are contained with the raw data and there are multiple checks

to insure that specific units cannot be identified in the processed data. For example, ARI, CALL, and the NTC Operations Group might separately check to see that confidentiality is maintained for a report. Use of the ATDL may be less centralized than use of the current CTC data archive and require a greater degree of ID removal before data are given to researchers.

The Need to Archive Planning, Communications, and Administrative Data Along with Other Data Types. One of the key concerns of researchers is documenting the conditions under which data were collected to make sure data are aggregated only when they are comparable. The actions of a unit must often be interpreted in terms of the complete METT-T situation that confronts a unit (Kerins, Atwood, & Root, 1990). Unfortunately there is a tendency to overestimate the capability of an electronic battlefield to support research. One assumes the capability to capture detailed data from the network (e.g., the direction in which gun tubes are pointed) guarantees the capability to examine these data and draw meaningful conclusions. However, users of such data rapidly discover how difficult it is to interpret data without information about the unit's plan for the mission, radio communications, and terrain features. To support research, planning data and communications data must be archived along with network data.

A lesson learned from the Multi-Service Distributed Training Testbed (MDT2) Project is that it is crucial to collect administrative data to support feedback and research applications of exercises. For example, the senior MDT2 trainer reduced the volume of artillery fire support missions requested by a unit to help keep the network data load from becoming too large. A researcher might reach erroneous conclusions by assuming that the volume of artillery fires directly reflects unit requests.

In another case during MDT2 data collection, the senior trainer used a "bomb button" to destroy an enemy vehicle targeted by an aircraft performing a CAS mission. The "bomb button" is frequently used in SIMNET exercises to remove entities from exercises by impacting a 500 pound bomb on the vehicle. The trainer decided that the pilot was doing everything right and the original bomb should have resulted in damage or destruction of

the vehicle. The problems analyzing the data stream after this exercise begin when one realizes that the number of bomb releases is less than the number of impacts.

The Need to Summarize the Contents of an Exercise. Another concern of researchers is that of reducing the amount of data that need to be examined. Again, the capability to operate and collect data in an electronic format deludes researchers into believing that these data can be examined quickly. This is true only if one does not have to rely on a complete replay of the data stream to compare one exercise with another. To the extent that data analysis tools are available to remove the need for complete replays, the electronic data format can be beneficial.

In a recent meeting on AAR capabilities, the Project Manager for Combined Arms Tactical Trainer (PM-CATT) expressed the need for an archiving system that provides a summary of exercise events that supports analyses of data across exercises. As he pointed out, trying to analyze data by replaying entire exercises is just too cumbersome and time-consuming.

Standardizing DIS Data Logger File Formats. ARI, and other organizations, have encountered problems in trying to use archived data from SIMNET exercises because multiple archiving formats are in use. The Institute for Defense Analysis (IDA) and STRICOM recognized the need for standardizing the format of DIS data logger files and a working group led by STRICOM developed a standardized file format (Garnsey, et al., 1995).

In addition to standardizing the format of data files, this effort also started the job of including non-network data necessary to interpret network data in the logger file. Examples of non-network data include the identification of the terrain database used for the exercise, the type of mission being executed, the unit's plans for the operation, and unit map overlays and graphics (e.g., showing the locations of control measures).

A first draft of the standard file format is available through the Tactical Warfare Simulation and Technology Information Analysis Center (TWISTIAC). The process of testing and refining the standard data logger format is expected to continue in the immediate future. From the perspective of human

performance analysis, two of the major issues to be addressed are whether the format includes all of the types of non-network data required to support performance analysis and the amount and variety of network data collected is excessive.

An important lesson learned from the UPAS project has been that the entire PDU stream is not necessary to support performance analysis. The high frequency at which entity status data must be sent over the network to support a simulation goes well beyond what is required for analysis. Time sampling techniques can be used to reduce the size of exercise data files.

The need for an archiving system that increases the efficiency of research can be met to an extent by using a strategy developed within the UPAS project. The UPAS employs two databases, a logger file capable of driving exercise replays and a set of relational database tables used to support data analyses. Menus of data summary table and graph options are integrated with the relational database to support analyses, and the menus can be modified or expanded by users. For archiving purposes, only the logger file needs to be saved. The relational data tables can be quickly generated from the logger file to support analyses using the menus of table and graph options. Having exercise data in relational data tables makes it possible to combine exercise data across exercises in a format that supports analyses across exercises.

Archiving of Performance Measures. At the present time there is no centralized source of information regarding measures of performance that have been used in the DIS environment. BDM Corporation, under the sponsorship of ARI, undertook a brief effort to define the concept for a DIS Taxonomy of On and Off-Line (DIS-TOOL) Performance Variables (Winsch, Clifton, & Atwood, in preparation). As the name suggests, this taxonomy was intended to deal with non-network data (off-line) as well as network data (on-line).

The general concept called for archiving of measures of performance (MOP) and historical data on the use of the MOP. One of the major goals of the taxonomic system was to find a way of structuring the archive in a way to help a wide variety of users (combat developers, computer generated force developers, materiel developers, training developers, and operational test and

evaluation developers) to identify MOP relevant to their objectives. Plans called for using advocates for each potential user group in the development of the taxonomy to insure the structure and terminology used for the system fit each group.

This effort was terminated due to a lack of funding in the early stages of taxonomy development. The need for the product has not diminished.

Summary

The requirement to provide data for the ATDL might make it necessary to impose certain features on the STAARS in order to safeguard the identity of units. Then again, responsibility for safeguarding this information might reside with the ATDL component.

In order to interpret the data stream collected by STAARS in the context of research applications it will be necessary to supplement the network data with unit planning data, information about the computer generated force used to support the exercise, and data on trainer/exercise director interventions during the exercise. All three training environments have been used to support combat developments testing in the past, so there are groups of researchers we can call upon to identify information that must be added to network data streams to support research applications. STAARS developers should also provide input to ongoing efforts to standardize logger file formats. Efforts to identify the information needed to support research applications of STAARS data would be facilitated if we had an archive of measures of unit performance used in the three training environments, but no such archive exists.

Recommendations

Add the capabilities described below to the STAARS ORD.

- o The system must support easy removal of unit and simulator identifier data.

- o The system must support the recording of information about trainer or work station operator interventions during exercises (e.g., a trainer or operator uses a bomb button

to destroy a threat to a unit so the unit can continue executing its mission) in a manner that allows these interventions to be correlated in time with other exercise events.

o The system must support the recording of planning data and observational data in a manner that allows these data to be correlated in time with other exercise events.

Interoperability Concerns

Background

The Workshops on Standards for the Interoperability of Distributed Simulations are concerned with specifying the capabilities a system must have to interoperate with other systems in the DIS environment. However, compliance with the standards produced through these workshops is only part of the requirements that must be met to make sure simulation systems can effectively share the same AAR system.

The data packets a system must be able to produce and react to in supporting an interactive simulation are required for a system to be DIS compliant. There are other data packets falling under the rubric of "simulation management" that are optional rather than being required (IEEE, 1993). Many of the data packets falling in this class were developed specifically to support performance measurement applications, such as AARS. Further, systems are free to vary in terms of the manner in which they convey information about a specific event. Using an AAR system to collect data from across a mixture of simulators will require a greater degree of standardization than that required for DIS compliance.

STAARS and DIS Standards Guidance

The STAARS MNS requires that the STAARS support training with all collective training systems, but the MNS does not specify what is required to operate effectively across systems. On the other hand, the primary purpose of the DIS Standards Conferences is to promote interoperability.

Status of Research

Data Communication Protocols. CCTT will be the first system to be fielded as part of the Army's Combined Arms Tactical Trainer (CATT) family, and it will employ DIS protocols rather than SIMNET protocols. Future members of the CATT family must be interoperable with CCTT to allow the linking of CATT systems in a single exercise. CCTT must also be interoperable with SIMNET to allow SIMNET and CCTT to be linked in common exercises in the near future (U.S. Army Armor School, 1990).

One of the earliest problems implementing DIS protocols concerned the loss of a direct replacement for the SIMNET Change of Status PDU. Under SIMNET, this PDU was generated by an entity when it went through a major change in status (damaged, destroyed, reincarnated), and it conveyed information about the nature of the status change, the cause of the status change, and specific entities responsible for the change (Pope & Schaffer, 1991). The data from this PDU could be used, for example, to find out that BLUFOR tank A11 was destroyed by fire from REDFOR tank B12 at 16:33:10. Without this PDU, the data analysis system must recreate events to find out why a status change occurred and who was responsible for the change (Meliza, 1995). This gap in the data stream was one of several identified when attempting to produce exercise data summaries specified in the CCTT requirements document (Lacy, Tuttle, & Meliza, 1994).

The solution to the information gap associated with the loss of the Status Change PDU was to implement a version of the DIS Event Report PDU that replaces the Status Change PDU. This implementation is described in the CCTT Interoperability Description Document (Sherikon, 1995). In order for other training devices to link with CCTT in common exercises where AAR aids cover damage inflicted by all players, these other devices must be programmed to generate the same version of the Event Report PDU generated by CCTT.

We can expect additional problems and solutions to emerge regarding communication protocols over the next several years, due to the fact that we are continually making the DIS environment more realistic by adding new entities and expanding the environmental models used in the DIS environment. We will again find that some of the aspects of behavior we want to measure cannot be measured easily without changes in the network data stream.

Terrain Databases and Other Environmental Models. SIMNET was very primitive in terms of the play of environmental variables (e.g., day/night, wind, rain, electromagnetic spectrum). Over time, we are adding the capability to provide greater variation in environmental variables and entities that can respond to these variations. The capability of any one training device to realistically play all environmental variables is restricted by limits in processing power, so most training devices are likely

to emphasize those environmental variables considered most critical to the device proponent. For example, ground forces will want detailed play of terrain variables, while air forces will want detailed play of the electromagnetic spectrum.

To properly interpret exercise data, one must have information about the sensitivity of entities to the various environmental models and information about the detail of these models. The job of collecting information grows in complexity as individual training devices become more sophisticated and as the mix of training devices included in an exercise become more heterogenous. Very little progress has been made regarding methods for collecting and interpreting information about environmental models except for terrain database correlation (Spuhl & Findley, 1994).

The Chemical, Biological, and Radiological (CBR) Models and Simulation Consortium is expanding terrain models and entity behaviors to address CBR contamination to support DIS applications to combat developments testing. This group plans to use STRIPES as an AAR system, and it expects to modify STRIPES source code to support performance measurement in a more complex battle space. The consortium includes the U.S. Army Chemical School, Natick Research Development and Engineering Center, the U.S. Army Nuclear and Chemical Agency, the Ballistic Missile Defense Organization, U.S. Army Research Laboratory, PM Smoke and Obscurants, PD Bio Defense, PM NBC Defence, TRADOC Analysis Command, Naval Surface Warfare Center, Institute for Defense Analysis, Defence Nuclear Agency, and the Dismounted Battlespace Battlelab.

Computer Generated Forces (CGF). As previously mentioned in this report, memories and knowledge of exercise participants are important sources of information for AARs. The memories/ knowledge that are important includes those from sister units with which the unit works in performing collective tasks, and it includes information from the opposition force. This is true whether the sister unit and opposition force are composed of manned units or CGF.

Information about when a CGF detects, identifies, and recognizes another force is not broadcast over the network so that it can be picked up by an AAR system. This information is

retained in the internal database of at least some CGFs. These data might be loaded directly from the CGF to the AAR system, but, because each CGF differs in terms of the manner in which these data are stored internally, this approach would require software unique to each type of CGF. Alternatively, CGFs might be required to send out the required information over the network, using an Event Report PDU or similar DIS simulation management PDU. There is a need for the Army to decide what information it needs from CGFs and select the most efficient means of collecting that data for use on an AAR system.

Proper interpretation of exercise data in which a CGF is involved, especially for test purposes, requires information about the rules controlling the behavior of the CGF. These rules will vary from one CGF to another. For example, in comparing sensitivity to terrain features of ModSAF Version 1.2 with SAFOR Version 4.3.3, Meliza and Vaden (1995) found the speed of ModSAF entities varied as a function of terrain, while the speed of SAFOR entities was largely insensitive to terrain. In a case where a ModSAF and SAFOR vehicles moved over the same terrain with inclines and declines of as much as 40 percent, the SAFOR vehicle spent 98 percent of the time traveling at a speed of 29 km/h. The ModSAF entity demonstrated the distribution of speeds shown in Table 1.

Table 3. % of Time MODSAF Tanks Spent Traveling at Various Speeds

Speed (Km/Hr)	% of Time Moving at This Speed	Speed (Km/Hr)	% of Time Moving at This Speed
1	1%	26	1%
3	1%	27	1%
8	1%	28	1%
9	1%	29	1%
10	1%	30	1%
12	1%	32	1%
13	1%	33	1%
14	2%	35	2%
15	1%	36	54%
16	6%	37	2%
17	2%	38	1%
18	1%	39	1%
19	1%	50	1%
20	1%	62	1%
22	1%	73	1%
24	1%	76	1%
25	2%		
28	1%		

<u>Summary</u>

The standards being developed within the Workshops on Standards for the Interoperability of Distributed Simulations are a starting point for addressing interoperability issues relevant to AAR systems. The major benefit derived from the standard is to ensure commonality in terms of the generation and interpretation of network data used to directly support simulations (e.g., entity PDUs). Benefits are also gained by providing a common framework for the simulation management PDUs carrying data relevant to performance measurement, but to take advantage of this framework requires further standardization in the way these PDUs are implemented. For Army systems, the specific implementations required to ensure interoperability are defined in the CCTT interoperability document (Sherikon, 1995).

In addition to standardizing the network data stream, attention must be paid to comparing the environmental models used by various simulations, such as the terrain databases. Attention must also be paid to comparing the sensitivity of systems, including various computer generated forces, to environmental and network variables.

Recommendations

The STAARS ORD should require that any AAR system expected to use the DIS data stream be capable of interpreting the CCTT implementations of the simulation management PDUs.

At the present time it is difficult to state what an AAR system must be capable of doing to take advantage of information from CGFs. Research is required to identify the best methods for collecting what is currently non-network data from CGFs to support unit performance measurement for AAR, THP, and research applications.

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Appendix A: Acronyms

AAR	After Action Review
ARI	Army Research Institute for the Behavioral and Social Sciences
ARNG	Army National Guard
ATDL	Army Training Digital Library
ATAFS	Automated Training Analysis and Feedback System
ATAFS-AT	ATAFS Authoring Tool
CBS	Corps Battle Simulation
CGF	Computer Generated Force
CALL	Center for Army Lessons Learned
CAS	Close Air Support
CATT	Combined Arms Tactial Trainer
CBT	Computer-Based Training
CCTT	Close Combat Tactical Trainer
COTS	Commercial Off the Shelf
CTC	Combat Training Center
DARPA	Defense Advanced Research Projects Agency
DIS	Distributed Interactive Simulation
ENDEX	End of Exercise
IDA	Institute for Defense Analysis
LD	Line of Departure

METT-T	Mission, Enemy, Terrain, Troop, and Time
MNS	Mission Needs Statement
ModSAF	Modular Semi-Automated Force
MILES	Multiple Integrated Laser Engagement System
MTP	Mission Training Plan
MDT2	Multi-Service Distributed Training Testbed
MWTSC	Mounted Warfare Training Simulation Center (MWTSC)
NSC	National Simulation Center
NTC	National Training Center
O/C	Observer/Controller
ORD	Operational Requirements Document
PDU	Protocol Data Unit
POI	Program of Instruction
RCVTP	Reserve Component Virtual Training Program
REALTRAIN	Realistic Training
SAFOR	Semi-automated Force
SATS	Standard Army Training System
SCOPES	Squad Combat Operations Engagement Simulation
SIMITAR	Simulation in Training for Advanced Readiness
SIMNET	Simulation Networking
SOP	Standard Operating Procedures

STAARS	Standard Army After Action Review System
STOW	Synthetic Theater of War
STRICOM	Simulation, Training and Instrumentation Command
STRIPES	Simulation Training Integrated Performance Evaluation System
TADSS	Training Aids, Devices, Simulations, and Simulators
TES	Tactical Engagement Simulation
TOM	Teamwork Observation Measure
THP	Take Home Package
TRADOC	Training and Doctrine Command
TSP	Training Support Package
TTP	Tactics, Techniques, and Procedures
TWISTIAC	Tactical Warfare Simulation and Technology Information Analysis Center
UPAS	Unit Performance Assessment System